DESIGN BASIS REPORT
PERMEABLE REACTIVE BARRIER
GROUNDWATER
INTERIM MEASURE

prepared for

ArvinMeritor, Inc.
Troy, Michigan

May 2001

Docket Number 450430

DESIGN BASIS REPORT
PERMEABLE REACTIVE BARRIER
GROUNDWATER INTERIM MEASURE

GRENADA MANUFACTURING SITE
GRENADA, MISSISSIPPI

Prepared for:

ArvinMeritor, Inc.
Troy, Michigan

Prepared by:

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May 2001

19071.001

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May 18, 2001

27-19071.001

BROWN AND CALDWELL
Environmental Engineering & Consulting

Mr. Donald Webster
USEPA Region IV
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303-8960

RE: Grenada Manufacturing Facility
Grenada, Mississippi
USEPA ID No.: MSD 007 037 278

Dear Mr. Webster:

Enclosed for your review are two copies of the *Design Basis Report for the Permeable Reactive Barrier Groundwater Interim Measure* for the referenced site. Two copies have also been transmitted to the Mississippi Department of Environmental Quality (MDEQ). Sets of engineering drawings have also been provided with this report as Appendix B (although they are separate due to their size).

As stated in previous correspondence, this report describes the scope of the design effort, a summary of the relevant site conditions, the performance requirements of the permeable reactive barrier, and the design criteria for the wall. The various critical issues associated with this interim measure are discussed in the report. Other related documents associated with this design have not yet been completed. Technical specifications are being prepared that will allow prospective contractors to bid on this project. These specifications, along with the engineering drawings, will constitute the bid package for the project. Additionally, a Construction Quality Assurance Plan (CQAP) and a Performance Monitoring Plan will be prepared at the appropriate time. Both of these documents are discussed in the Design Basis Report.

As we have discussed in the past, the interested parties (i.e., Grenada Manufacturing, ArvinMeritor, and Textron) would like to construct this project during the upcoming drier summer months. Three tasks need to be completed to accomplish this:

- Response from the US Army Corps of Engineers on the Jurisdictional Determination for the site and compliance with applicable permitting requirements

- Completion of an access agreement for a portion of the project site

- Receipt of approval from the USEPA on this Design Basis Report

The request for a Jurisdictional Determination has been submitted to the Corps and we are awaiting the results. In addition, ArvinMeritor is in the process of negotiating an access agreement with the current owner of the property immediately south of the Grenada Manufacturing property along Riverdale Creek. ArvinMeritor is requesting that the agency expedite its review of this report and drawings in order to facilitate the overall schedule.

We look forward to hearing from you regarding this project. If you have any questions or comments, please feel free to call us at (615) 255-2288.

Sincerely,

BROWN AND CALDWELL

Dale R. Showers, P.E.
Project Manager
Design & Solid Waste

Robert E. Ash, IV, P.E.
Department Manager
Design & Solid Waste

cc: Louis Crawford, MDEQ
John Bozick, Arvin Meritor
Don Williams, Grenada Mfg.
John Kandler, Textron

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APPENDICES

FIGURES

PROFESSIONAL ENGINEER'S CERTIFICATION

This is to certify that the Design for the Permeable Reactive Barrier Groundwater Interim Measure at the Grenada Manufacturing, LLC Site was prepared under my direction and supervision.

Robert E. Ash, IV, P.E.
Registration No. 13005
State of Mississippi

5/18/01
Date

1.0 INTRODUCTION

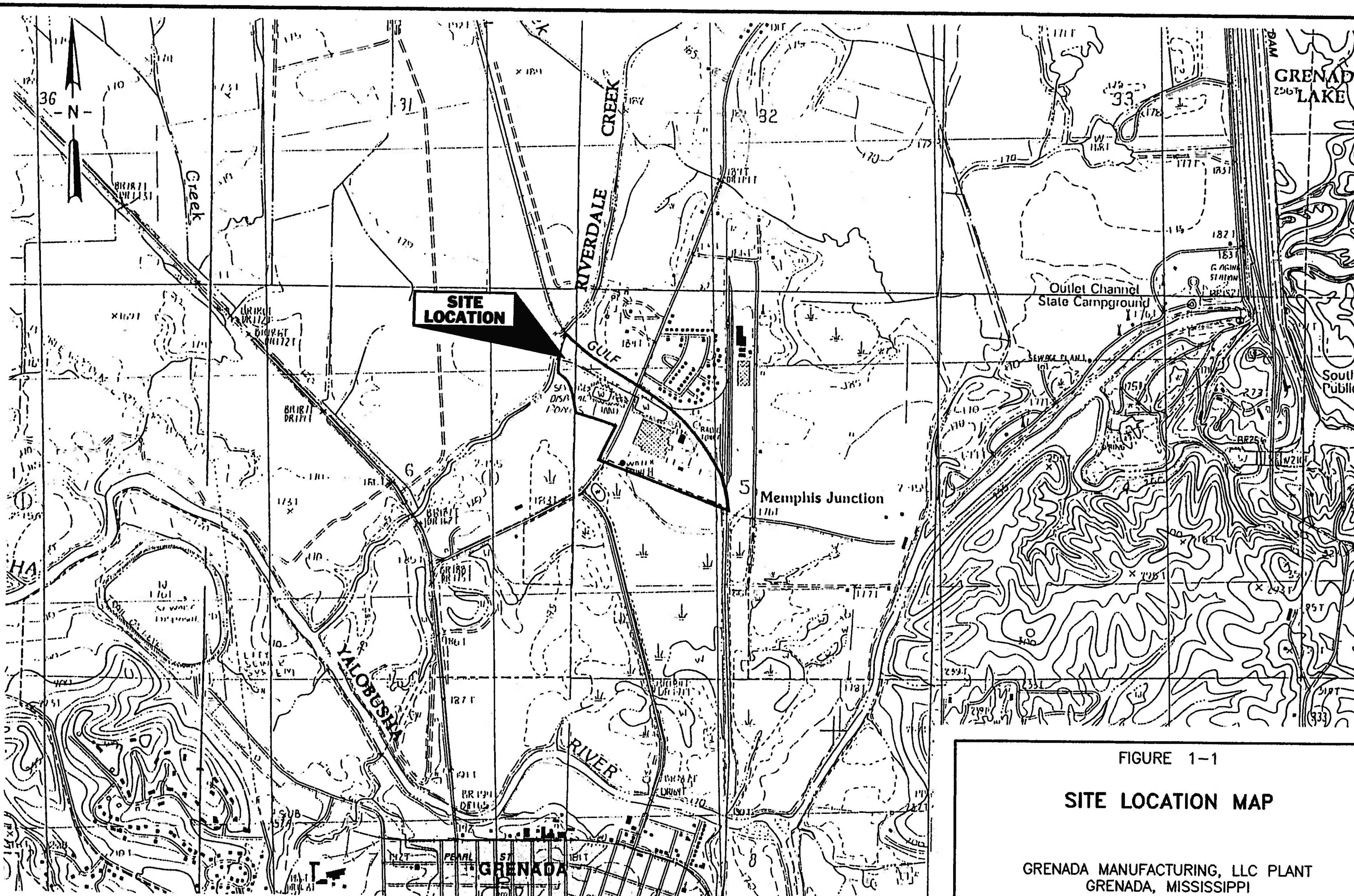
This document contains the design basis for groundwater interim measures for the Grenada Manufacturing, LLC facility (Site) located at 635 Highway 332, in Grenada, Mississippi (Figure 1-1). In accordance with the facility's Hazardous and Solid Waste Amendment (HSWA) Permit issued July 31, 1998, the facility is undergoing Resource Conservation and Recovery Act (RCRA) Corrective Action for prior and suspected ongoing releases of hazardous waste, including hazardous constituents from various solid waste management units (SWMUs). To that end, interim measures for the Site were required by the United States Environmental Protection Agency (USEPA) Region IV in its letter to Grenada Mfg. dated April 11, 2000. According to the letter, the USEPA requests that the facility address site-wide groundwater contamination, as well as source removal and soil contamination for the following SWMUs and Areas of Concern (AOC):

- SWMU 12 – Wet Well Sump
- SWMU 14 – Chromium Destruct Pit
- SWMU 15 – Process Sewers
- AOC A – Former Trichloroethylene Storage Area
- AOC B – Former Toluene Underground Storage Area

Figure 1-2 identifies these SWMUs and AOCs in relationship to existing Site features.

A project meeting was held on site April 25 and 26, 2000. During the project meeting, it was agreed that interim measures at SWMU 12 would not be necessary. As discussed with USEPA and the Mississippi Department of Environmental Quality (MDEQ), the Interim Measures Work Plan (June 2000) addresses priority SWMUs 14 and 15, AOCs A and B, and site-wide groundwater. SWMU 12 will be addressed indirectly through site-wide groundwater interim measures. This agreement is addressed in a USEPA letter to Grenada Mfg. dated May 18, 2000. The May 18 letter also mentions SWMU 13, the Wastewater Treatment Plant. However, this SWMU was noted in previous documents, including the April 11 USEPA letter, as not requiring interim measures.

The purpose of this Design Basis Report is to present the objectives of the selected interim measure and to document the decisions made during the detailed design. The primary objective of the



Modified from U.S.G.S., Grenada, Mississippi Quadrangle, 1983

FIGURE 1-1

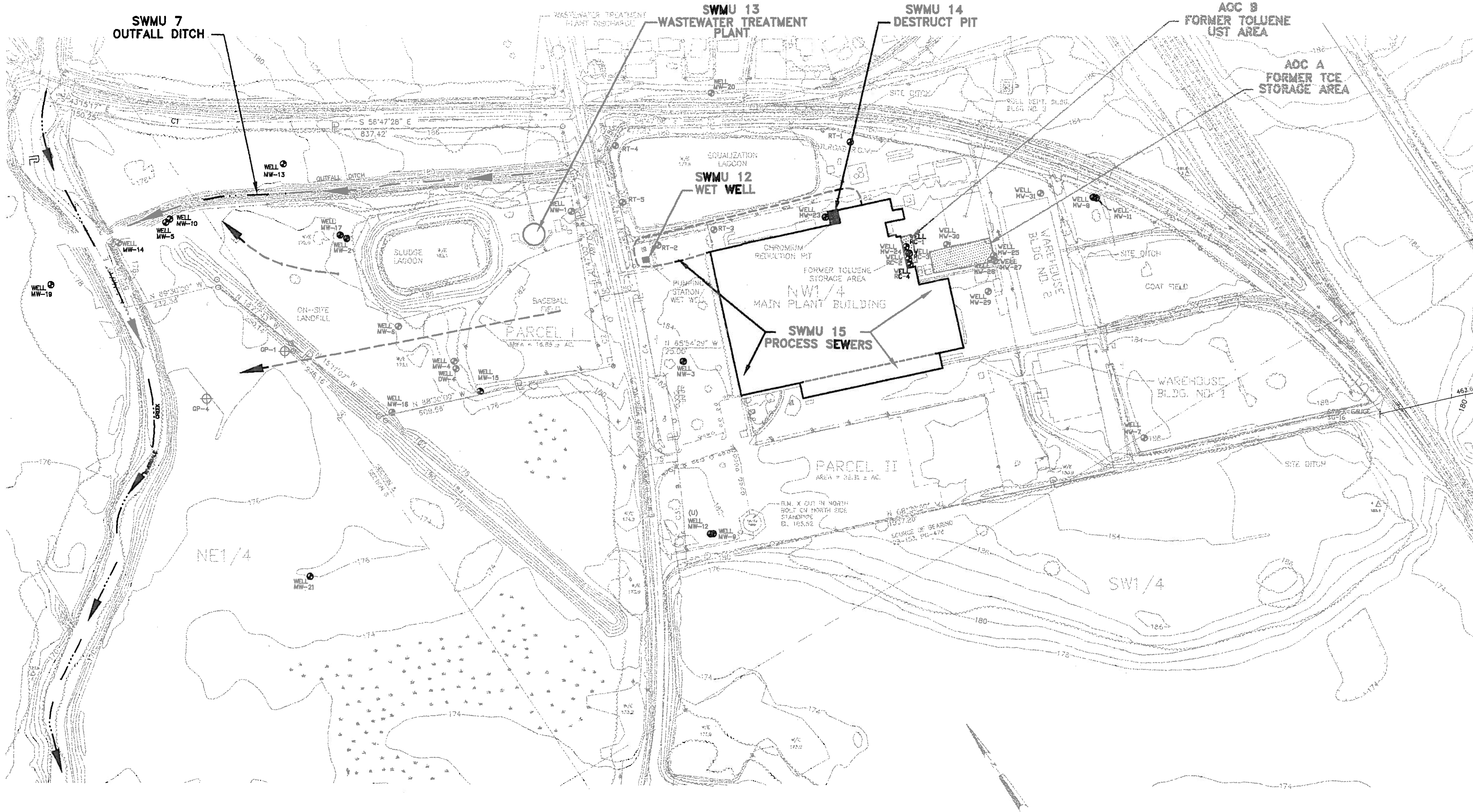
SITE LOCATION MAP

GRENADA MANUFACTURING, LLC PLANT
GRENADA, MISSISSIPPI

19071 05/01

BROWN AND CALDWELL Nashville, Tennessee

DRAWING NO.: 19071-00 DATE: 05/11/01 PLOT SCALE 1=1



LEGEND

- Monitoring Well
- Geoprobe Piezometer
- Groundwater Flow Direction
- Surface Water Flow Direction

PRIORITY SWMUs

12–WET WELL
13–WASTEWATER TREATMENT PLANT
14–CHROME DESTRUCT PIT
15–PROCESS SEWERS

PRIORITY AOCs

A–FORMER TRICHLOROETHYLENE STORAGE AREA
B–FORMER TOLUENE UNDERGROUND STORAGE AREA

SCALE 250 0 250 500 FEET

SOURCE: MAP PREPARED BY ALMON ASSOCIATES, 1993. WELL LOCATIONS SHOWN ARE APPROXIMATE.

FIGURE 1–2

SITE MAP SHOWING LOCATIONS OF PRIORITY SOLID WASTE MANAGEMENT UNITS AND AREAS OF CONCERN

GRENADA MANUFACTURING, LLC PLANT
GRENADA, MISSISSIPPI

19071.001 05/01

BROWN AND CALDWELL Nashville, Tennessee

DRAWING NO.: 19071–011 DATE: 05/11/01 PLOT SCALE 1=250 selected groundwater interim measure is to minimize or prevent the further migration of contaminants, and to limit actual or potential human and environmental exposure to contaminants while long-term corrective action remedies are evaluated. Section 2.0 of this report summarizes the results of pre-design efforts performed to address data gaps previously identified. Section 3.0 summarizes the design criteria for each component of the interim measure, while Section 4.0 describes the plan for satisfying permit requirements. Section 5.0 presents a preliminary construction schedule, and Sections 6.0 and 7.0 address construction quality assurance and performance monitoring, respectively.

1.1 BACKGROUND

Rockwell Automotive North America, now Arvin Meritor, Inc., operated a wheel cover manufacturing facility in Grenada, Mississippi from 1966 to 1985 before selling the operations and property to Textron Automotive Company, formerly Randall Textron, who then sold the operations and property to Grenada Manufacturing, LLC in 1999. Grenada Mfg. (Permittee) continues to operate the wheel cover plant. Arvin Meritor and Textron have conducted a number of environmental investigations at the referenced facility. The most extensive investigative work is reported in the 1994 Remedial Investigation (RI) Report conducted by ECKENFELDER INC., now Brown and Caldwell (BC). The work was performed in response to an MDEQ Administrative Order on Consent designed to investigate the on-site landfill, and was subsequently expanded to include other areas of the Site.

The 1994 RI Report detailed the sampling and analysis of soil, surface water, sediment, and groundwater at the facility. The report contained a description of the Site, including its geology and hydrogeology, as well as the sampling and analysis work that was conducted. The results of the investigation were discussed on a site-wide basis, because SWMUs and AOCs had not yet been determined. In addition to soil and groundwater impact, two areas containing free-phase organics, light non-aqueous phase liquid (LNAPL) and dense non-aqueous phase liquid (DNAPL), were identified.

The RI identified the presence of trichloroethylene (TCE) and its degradation products, as well as toluene and chromium, in the soil and groundwater at the Site. A Baseline Risk Assessment was performed for soil and groundwater as part of a Supplemental RI (March 1994). The primary concern with respect to impacted groundwater is the migration of chlorinated volatile organic compounds (VOCs) to Riverdale Creek on the west side of the Site. The baseline risk assessment identified 8 VOCs (1,2-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene (total), tetrachloroethene, toluene, 1,1,2-trichloroethane, trichloroethylene, and vinyl chloride), 1 semi-volatile organic compound (bis 2-ethylhexyl phthalate), and 2 metals (chromium VI and arsenic) as constituents of concern.

Subsequent to the submittal of the RI Report, the facility became subject to regulation under RCRA. A RCRA Facility Assessment (RFA) was performed by the USEPA and its contractor (A.T. Kearney, Inc.) as part of the HSWA permit process for the facility in 1996 and 1997. As a result of the Preliminary Review (PR) and Visual Site Inspection (VSI), 26 SWMUs and 3 AOCs were identified.

In 1998, Arvin Meritor collected another set of groundwater samples to determine VOC concentrations and to evaluate the potential for natural attenuation to contribute to a remedy for groundwater. Analyses included VOCs and bioremediation parameters recommended in the USEPA document "Technical Protocol for Evaluating Monitored Natural Attenuation of Chlorinated Solvents in Ground Water". The data are presented in a January 1999 report by BC entitled "Supplemental Groundwater Sampling and Analysis: Natural Attenuation Evaluation".

In March 1999, USEPA issued a combined RCRA Facility Investigation (RFI)/Confirmatory Sampling (CS) Work Plan call letter. Arvin Meritor and Textron requested a meeting at the USEPA office to review the results of the RI and to identify potential data gaps. During a meeting held in May 1999, it was agreed that nearly all of the information that might be generated in an RFI/CS effort already existed. USEPA requested that summaries of data obtained subsequent to issuance of the RI Report be prepared and that the available data be organized by SWMU or AOC. Specifically, summaries documenting media-specific concentrations were requested for priority SWMUs 7, 12, 13, 14, and 15, and AOCs A, B, and C. A Summary of Investigative Work (SOIW) document was prepared by BC in response to that request and was transmitted to USEPA and MDEQ in July 1999. Comments on the SOIW were received from the USEPA in its April 11, 2000 letter. As stated in the April 2000 letter, Grenada Mfg. was required to respond to USEPA comments on the SOIW and to revise and resubmit the SOIW as the Draft RCRA Facility Investigation (RFI) Report.

Additional data have been obtained during various post-closure activities and in conjunction with interim measures. These data are documented in several reports, which have been previously submitted to the USEPA and/or MDEQ. During the meeting held at Grenada Mfg. in April 2000, the results of these previous investigations and interim measures were discussed and it was concluded that Site information was insufficient to complete the evaluation of interim measures. Therefore, additional soil and groundwater data collection was proposed. The USEPA, MDEQ, Grenada Mfg., Arvin Meritor, and BC agreed that additional groundwater sampling would be performed to update the groundwater database and incorporate the updated information into the RFI Report (revised SOIW).

An Interim Measures Work Plan was submitted in June 2000 and approved in July 2000 by the USEPA. The Interim Measures Work Plan addressed additional data collection and the evaluation of interim measures for both source control and site-wide groundwater. The additional data collected would be reported in the RFI Report and used in the evaluation of interim measures. Accordingly, a site-wide groundwater-sampling event was conducted in October 2000 to update the groundwater database. Twenty-five (25) monitoring wells were sampled and analyzed for VOCs, semi-volatile organic compounds, target analyte list metals, and hexavalent chromium to assess groundwater quality at the Site. The RFI Report, including responses to USEPA comments on the Draft SOIW and the results of the additional sampling, was transmitted to the USEPA and MDEQ on January 31, 2001.

Concurrent with the October 2000 groundwater sampling event, additional groundwater sampling using direct-push technology was conducted to provide additional data. The objective of the direct-push groundwater sampling was to determine the lateral and vertical extent of the groundwater plume along Riverdale Creek and to determine the elevation of the top of the aquitard. Seven direct-push sampling locations were used to meet data needs. The sample locations were positioned strategically between the extent of the plumes (as identified prior to sampling) and Riverdale Creek to assess the presence of constituents of concern. Additionally, two piezometers were installed near Riverdale Creek to supplement groundwater elevations and flow estimates.

Groundwater analyses were performed in accordance with the updated Quality Assurance Project Plan (QAPP) for the Site, which was approved by the USEPA in December 2000. A review of the TCE data indicates that, in general, the groundwater quality has changed little over the period 1993 to 2000 with the exception of select monitoring wells, particularly some located adjacent to Riverdale Creek, which showed an increase in TCE concentration. Concentrations of chromium have remained relatively unchanged. Chromium VI concentrations, however, have declined and have fallen below the site risk-based action level of 0.14 mg/L. In general, the new groundwater data suggest the need for additional groundwater interim measures at the Site.

1.2 INTERIM MEASURES EVALUATION

TCE and its degradation products currently impact a large portion of the Site groundwater. Additionally, there is a significant portion of the Site where chromium impacts groundwater. Groundwater at the Site appears to discharge primarily directly to Riverdale Creek. Potential impact to the creek appears to be limited to TCE and its degradation products. Groundwater may also enter the outfall ditch, which discharges to Riverdale Creek. Impact to Riverdale Creek due to discharge of groundwater containing TCE and its degradation products has been identified as an environmental condition that could significantly benefit from implementation of interim measures.

A number of source control interim measures have been previously implemented at the Site. These measures include installation of a DNAPL recovery system for TCE at AOC A, installation of an LNAPL recovery system for toluene at AOC B, and ex-situ soil vapor extraction at the On-Site Landfill Area (SWMU 4). NAPL recovery efforts were initiated in 1993. These activities included the installation and operation of automated DNAPL and LNAPL recovery units in wells located at AOC A and B, respectively. The amount of NAPL recovered from these areas decreased over the years to levels where automated systems are no longer effective. Currently, NAPL is removed manually (i.e., using bailers) from the wells on a monthly basis. Previously performed source control measures have been successful in terms of meeting their intended objectives.

Grenada Mfg. expects to continue NAPL recovery as an interim measure. In addition, the Former Equalization Lagoon was closed under the oversight of MDEQ. The facility also is in the process of implementing another source control measure; specifically, shutdown of the existing chromium plating operation. Active chrome plating operations were discontinued on January 18, 2001. Use of the Chrome Destruct Pit (SWMU 14) for treating chromium-laden wastewater from the discontinued operations was completed by March 9, 2001. Grenada Mfg. submitted a Closure Plan for the associated sumps, pits, and the Chrome Destruct Pit on March 15, 2001. That Closure Plan identifies and discusses further closure steps. More detailed discussions regarding the previous, ongoing, and proposed source control measures are provided in the Interim Measures Work Plan.

There is one primary and a number of secondary potential remaining source areas for TCE, some of which may not be easily accessed. Addressing hot spots, particularly where DNAPL may exist, will have minimal impact on groundwater quality unless TCE removal/destruction exceeds 95 percent or possibly 99 percent. Unless all significant source areas are adequately treated, impact to groundwater is likely to continue. Currently, available technologies have not, in general, been able to meet this requirement. Thus, it is not likely that additional source area treatment on an interim basis would have near-term impact on the quality of groundwater reaching Riverdale Creek. If a measure capable of preventing impact to Riverdale Creek is implemented, then the potential environmental impact from source areas, as well as the site-wide groundwater plume, will be controlled. Thus, the focus of the identification and evaluation of interim measures has been on controlling the migration of groundwater impacted by TCE and its degradation products to the creek (i.e., migration control).

While the source control interim measures have provided obvious benefit to the Site, the October 2000 groundwater data suggest additional interim measures are appropriate near Riverdale Creek. Based on the results of the site-wide groundwater sampling event completed in October 2000, it appears that the constituent plume has migrated to Riverdale Creek. As such, it would appear that interim measures should consist of migration control measures and that the appropriate location for such additional interim measures would be near the creek. If necessary, migration control interim measures could later be combined with more aggressive source control measures as part of final corrective measures.

Because the most appropriate location of the additional interim measures appears to be near Riverdale Creek, the use of groundwater extraction and treatment options was not favorably considered due to the high volume of groundwater (in the absence of a barrier wall) that would be anticipated to be collected in such close proximity to the creek. Rather, proven in-situ treatment technologies were evaluated, including:

- Permeable reactive wall (i.e., zero valence iron)
- Air sparging curtain
- Enhanced bioremediation

These technologies have been evaluated for use at the Site both on an individual basis and in combination. Screening of applicable technologies was limited to known site and waste characteristics and technology limitations. A permeable reactive wall using zero valence iron filings was generally thought to be the most appropriate option for use at this Site and, therefore, it was used as a point of comparison for other options. The wall would likely be installed as a trench to the top of the underlying aquitard and would intercept the entire cross-section of the groundwater plume depicted by the October 2000 sampling data. The actual wall location, length, and thickness have been determined during this design phase and are outlined in Section 3.0. Based on available information, the permeable reactive wall may also address metal concentrations (e.g., hexavalent chromium) in the groundwater, although metals are not significant contributors to the groundwater plume in this area of the Site.

The results of this limited evaluation of these potential interim measures were documented for USEPA in a letter dated March 9, 2001. In general, it was determined that the permeable reactive wall is attractive for this Site due to its anticipated effectiveness, its lower overall costs, and its low operation and maintenance (O&M) requirements. Because these technologies were evaluated for potential use as an interim measure and because additional discussions regarding the applicability of various technologies has occurred in the past, this evaluation was limited to groundwater technologies that are known to have a good chance to work at the Site. This limited evaluation of potential interim measures does not constitute a full remedial technology evaluation (i.e., Corrective Measures Study (CMS)). A CMS will likely be performed for the Site at some future date and the results of the various interim measures will be considered as part of that study. However, this evaluation did include consideration of incorporating interim measures into final corrective measures. Other considerations for selection of interim measures included effectiveness, implementability, O&M requirements, and cost.

Subsequent to receiving concurrence from the agencies on the design of the selected groundwater interim measure, the various components will be installed. The system will then be monitored and its performance included in the overall CMS process for the Site.

2.0 SUMMARY OF PRE-DESIGN TASKS

To complete the detailed design components for the selected interim measure, two pre-design tasks were completed to provide the necessary information. These tasks include a focused geotechnical study and a bench-scale treatability study. Brief descriptions of these tasks and their outputs are provided below.

2.1 GEOTECHNICAL INVESTIGATION

The preferred method for installation of the permeable reactive barrier at this Site is the slurry trench method. The depth of the barrier wall is expected to be 45 to 60 feet below ground surface. These depths are greater than the capabilities associated with typical open trench methods or trenching equipment (i.e., one-pass trenchers). A focused geotechnical investigation was performed to obtain the soil data necessary for the design of the slurry trench. The investigation included soil borings down to the aquitard below the aquifer and the collection of soil samples at five boring locations along the proposed wall alignment. The soil samples were then submitted to a geotechnical laboratory to obtain the necessary design parameters. A geotechnical firm (QORE Property Science) was retained to collect and test the samples of the various soil layers or types. This work was performed between April 16 and May 4, 2001. The following tests were performed on the number of samples indicated:

- Unit Weight/Moisture Content — 8 samples
- Particle Size Distribution (Coarse Fraction Only) — 6 samples
- Direct Shear Strength (Non-cohesive Soil) — 3 samples
- Atterberg Limits (Cohesive Soil) — 1 samples
- Triaxial Shear Strength (Cohesive Soil) — 5 samples

A copy of the summary report from the geotechnical laboratory is included in Appendix A. A geologic profile of the subsurface along the alignment of the trench is included with the engineering drawings (Appendix B). The results of the soil testing were used to evaluate the trench stability for the slurry trench and to evaluate construction methods.

In general, the geology encountered during completion of the soil borings was similar to that described in previous reports for the Site. The soil profile encountered can generally be described as the following: the uppermost soil layer is generally a clayey silt or silty clay with a typical thickness of approximately 10 to 15 feet, the next soil layer encountered was typically a saturated fine to medium grained sand with varying amounts of silt with a thickness ranging from approximately 30 to 50 feet. In addition, throughout the drilling efforts the fine to medium grained sand exhibited the properties of a "running sand" and flowed into the hollow-stem augers despite the additional effort of keeping the augers filled with bentonite drilling mud. Silty layers ranging in thickness from a few inches to approximately 5 feet were encountered in the sand unit at varying frequencies and depths. Blow count values and visual descriptions obtained during split-spoon sampling indicate these silty layers are relatively weak and consist primarily of saturated very fine sand and silt. Thinly bedded, slightly sandy, clayey silt was encountered below the sand layer at depths ranging from 47 to 60 feet below the ground surface. This layer has previously been identified as marl and it exhibited much higher blow count values than the soil encountered above it.

The results of the geotechnical laboratory testing generally supports the observations made during completion of the soil borings. Triaxial shear and direct shear testing were performed on relatively undisturbed samples (Shelby tubes) collected during performance of the soil borings. The results of this testing generally indicate that only the uppermost soil unit exhibited significant cohesion values, that the effective angle of internal friction for the relatively silty layers ranged from 0.6 to 40 degrees, and that the effective angle of internal friction of the sand unit ranged from 31.3 to 43.2 degrees. Grain size distribution test results indicate that the sand unit is comprised primarily of fine grained sand with lesser amounts of medium grained sand and with a fines content ranging from 4 to 24 percent. Porosity values of the sand unit were determined to range from approximately 38.5 to 45.7 percent. Soil properties are shown on the permeable reactive barrier profile sheet in the Engineering Design Drawings (Appendix B).

2.2 BENCH-SCALE TREATABILITY STUDY

A bench-scale treatability study was conducted by EnviroMetal Technologies, Inc. beginning in April 2001. The study was commissioned to evaluate the effectiveness of commercially available granular iron material for treating groundwater collected from the Site. The EnviroMetal Process is a metal enhanced reductive dehalogenation process that will degrade the VOCs and chromium present in the Site groundwater. EnviroMetal Technologies was founded specifically for the purpose of marketing and implementing this patented technology and has been granted exclusive commercialization rights by the patent holder (the University of Waterloo). EnviroMetal Technologies has access to the expertise and resources of the University of Waterloo and sponsors ongoing research of the technology. They typically act as a subconsultant and/or subcontractor and have staff that assist in design, installation, and evaluation of information. Senior staff at EnviroMetal Technologies have been involved with the technology from its initial development and are among the most experienced professionals in the application of permeable reactive barriers.

The bench-scale treatability study typically involves a laboratory column test to establish site-specific constituent degradation rates, which enables the prediction of system performance and provides data for field design. The degradation rates determined from the column tests are used to determine the required residence time in the granular iron. Using the residence time and the expected groundwater flow rate, the flow-through thickness of the permeable reactive barrier is determined. The column test also includes inorganic sampling of column influent and effluent which provides information concerning potential mineral precipitation in the reactive material caused by changing redox potential (Eh) and pH conditions. The potential for mineral precipitation will also be considered in the design of the wall.

Almost 50 liters of Site groundwater was collected from monitoring well MW-5 located near the intersection of Riverdale Creek and the stormwater ditch. Monitoring well MW-5 was selected because of its proximity to the proposed alignment for the permeable reactive barrier and the fact that constituent concentrations historically detected in that well represent moderate to high levels. The water was transported to the laboratory at the University of Waterloo in Canada for conduct of the study under the supervision of EnviroMetal Technologies. Preliminary data on the groundwater from the individual containers shows the following constituent concentrations:

- Tetrachloroethene — 28 to 34 μg/L
- Trichloroethylene — 50,000 to 68,000 μg/L
- 1,1 Dichloroethylene — 35 to 70 μg/L
- Cis 1,2 Dichloroethylene — 26,000 to 37,000 μg/L

- Trans 1,2 Dichloroethylene 250 to 350 μg/L
- Vinyl Chloride 74 to 160 μg/L
- 1,1,2 Trichloroethane 65 to 93 μg/L

The Site groundwater is passed through a column containing iron filings at a laboratory rate that is selected to approximate groundwater flow velocity at the Site. For this treatability study, a flow rate of 2 feet per day was used. This rate is roughly twice that estimated in the field; however, a quicker rate is necessary to complete the treatability study in a timely manner relative to design. Constituent concentrations are measured along the column until a steady-state profile is achieved. Eh and pH profiles are also measured periodically during the test. Inorganic parameters are monitored to help predict possible mineral precipitation.

EnviroMetal Technologies has identified and utilized two sources of granular iron material – Connelly-GPM, Inc. in Chicago and Peerless Metal Powders & Abrasive in Detroit. EnviroMetal Technologies recently completed side-by-side column tests to evaluate the degradation rates of VOCs in the presence of iron from both sources. The tests showed that the degradation rate for TCE with iron from both sources was similar. The degradation rates with the Connelly-GPM iron for cis-1,2 dichloroethylene and vinyl chloride were approximately 2 and 4 times faster, respectively. Since cis-1,2 dichloroethylene is present at high concentrations in the Site groundwater and will also be produced from the degradation of TCE, the degradation rate of the cis-1,2-dichloroethylene will be an important design parameter. Less Connelly-GPM iron will, therefore, be required to degrade the VOCs to the treatment criteria (i.e., MCLs). As the cost of iron from both Connelly-GPM and Peerless is comparable, iron from Connelly-GPM was used in the bench-scale test and will likely be used for the full-scale design at this Site.

The results of the bench-scale treatability study will be used to calculate constituent degradation rates and estimated residence time requirements for the field application. This information will, in turn, be used to establish the dimensions (i.e., the thickness) of the permeable reactive barrier. Because the test started on April 20, 2001 and requires approximately 60 days (the time required to pass 40 pore volumes through the column) to reach equilibrium, only preliminary half-lives are available at this point to estimate the amount of iron needed to reduce constituent concentrations.

As necessary, these estimates will be modified based on results obtained at the completion of the bench-scale study.

Based on existing Site data, preliminary estimates can be made to obtain the necessary design parameters. The residence times required were estimated using degradation rates from databases maintained by EnviroMetal Technologies, the VOC concentrations at the Site, and preliminary treatment goals (i.e., MCLs). The use of preliminary treatment goals set as low as MCLs for the purpose of the treatability study allows for the evaluation of other applicable goals that may be higher than the MCLs. Two scenarios were considered by EnviroMetal Technologies in estimating the required residence times: one using the maximum VOC concentrations observed in the vicinity of the wall and a second using moderate VOC concentrations. Certain inorganic compounds at high concentrations may have an adverse impact on the degradation of VOCs by granular iron. However, based on the range of concentrations of inorganic compounds in the vicinity of the wall, it is not anticipated that the inorganics will have an effect on the degradation rates. This is being evaluated as part of the treatability study.

Based on Site data provided by BC, EnviroMetal Technologies has estimated that residence times will be about 2.7 days and 2.0 days for VOC concentrations to reach treatment goals based on maximum concentrations and moderate concentrations, respectively. Using an estimated groundwater flow velocity for the Site of about 0.72 feet/day, granular iron thicknesses of 2 feet and 1.5 feet will be required to treat the maximum and moderate concentrations, respectively. Actual trench width will be approximately 2.5 feet (i.e., wider than the minimum thickness of 100 percent iron). The space difference between the necessary iron thickness and the actual wall thickness will be occupied by sand. Therefore, while the overall wall thickness will remain constant at about 2.5 feet, the proportion of iron to sand will vary to meet the minimum needs for granular iron. These values are preliminary and do not include a factor of safety for variations in groundwater velocity or constituent concentration. Final design parameters will be obtained at the completion of the treatability study, which is scheduled for June.

3.0 DESIGN CRITERIA

A permeable reactive barrier is a simple, passive process that degrades a wide range of VOCs, including those found at this Site, has nontoxic end products, and requires no equipment or energy/power source. This technology offers long-term treatment of constituents at moderate capital costs and low O&M costs while allowing continued use of the property. Some of the factors affecting the overall cost include groundwater velocity, plume dimensions, site geology, required residence time, granular iron source, and the installation method. The requirements for the permeable reactive barrier are as follows:

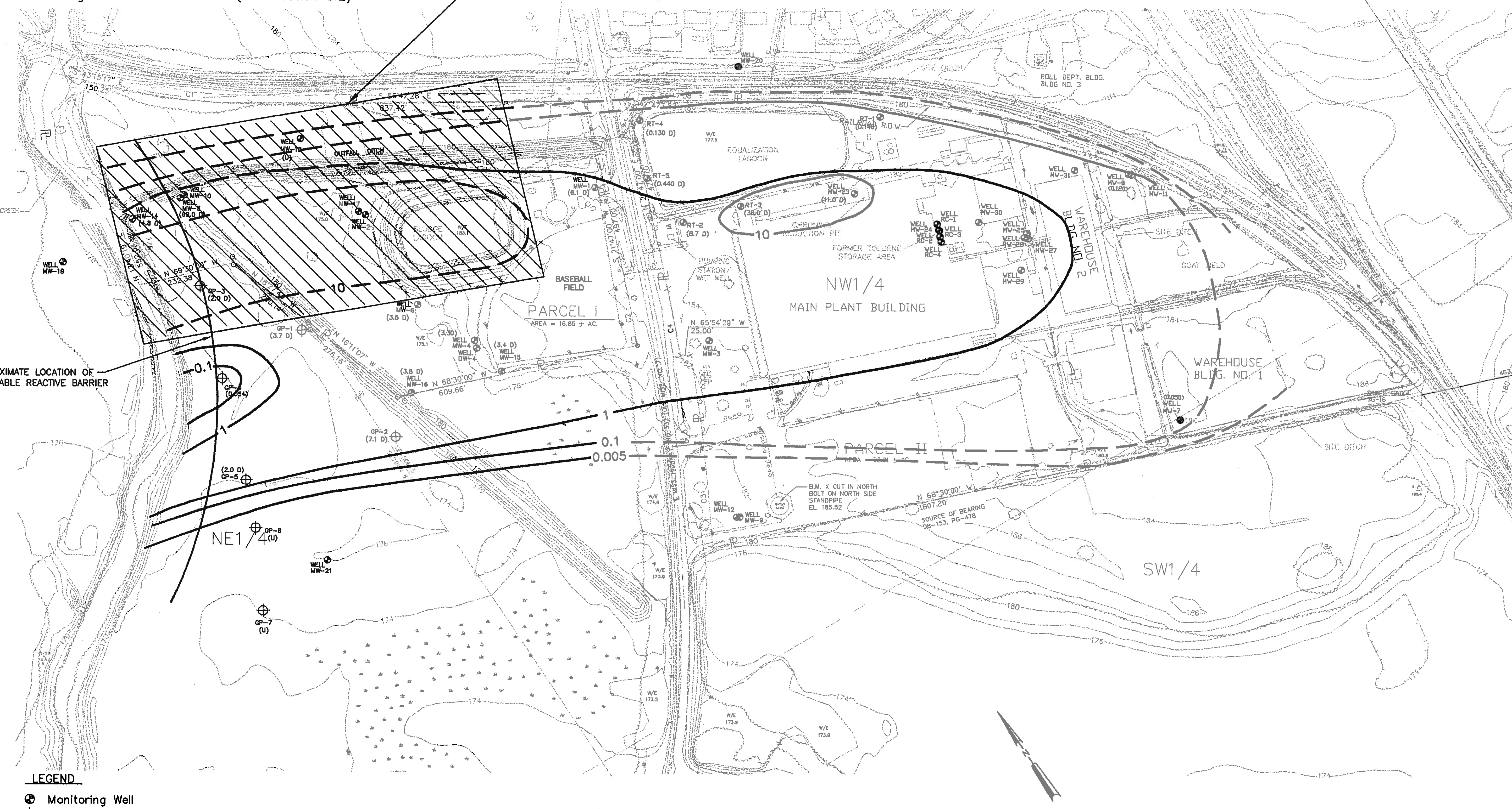
- Intercept the impacted Site groundwater prior to discharging to Riverdale Creek.
- Key into the competent clay layer underlying the uppermost aquifer at the Site.
- Reduce concentrations of constituents of concern to below established treatment levels.
- Achieve a higher hydraulic conductivity than the surrounding soil layers.

The results of a geotechnical investigation program and the preliminary results of a bench-scale treatability study were discussed in Section 2.0. The various required design criteria resulting from the completion of these efforts are described below.

3.1 WALL DIMENSIONS

The primary purpose of the permeable reactive barrier is to intercept impacted groundwater and reduce constituent concentrations prior to groundwater discharging into Riverdale Creek. To that end, the wall will be placed approximately parallel to the creek and will intercept Site groundwater with constituent concentrations above the respective MCLs (as depicted by the October 2000 site-wide groundwater sampling event) for the various constituents of concern. A review of the isoconcentration maps presented in the RFI Report (January 2001) indicates that the two maps depicting TCE concentrations represent the northernmost and southernmost boundaries of the various constituent plumes (see Figures 3-1 and 3-2). To intercept these plumes, the wall will be approximately 1,200 feet long. In addition, the wall will be continuous along the length and will not be constructed as a funnel and gate system. Because constituents are present in the groundwater over the entire vertical thickness of the saturated zone, the wall will extend from slightly above the

Projected Concentration (Based On October 2000 Sampling Data) After Partial Backfilling Of The Outfall Ditch. (See Section 3.2)



LEGEND

- Monitoring Well
- Geoprobe Location
- (0.05) Trichloroethene Concentration in mg/L
- (U) Non-Detection
- (J) Estimated Concentration
- (D) Diluted Sample
- Concentration Contour, mg/L (Dashed where inferred)
  Minimum contour is equivalent to the USEPA MCL.

NOTE: DNAPL was observed in monitoring well MW-2.

SOURCE: MAP PREPARED BY ALMON ASSOCIATES, 1993. WELL LOCATIONS SHOWN ARE APPROXIMATE.

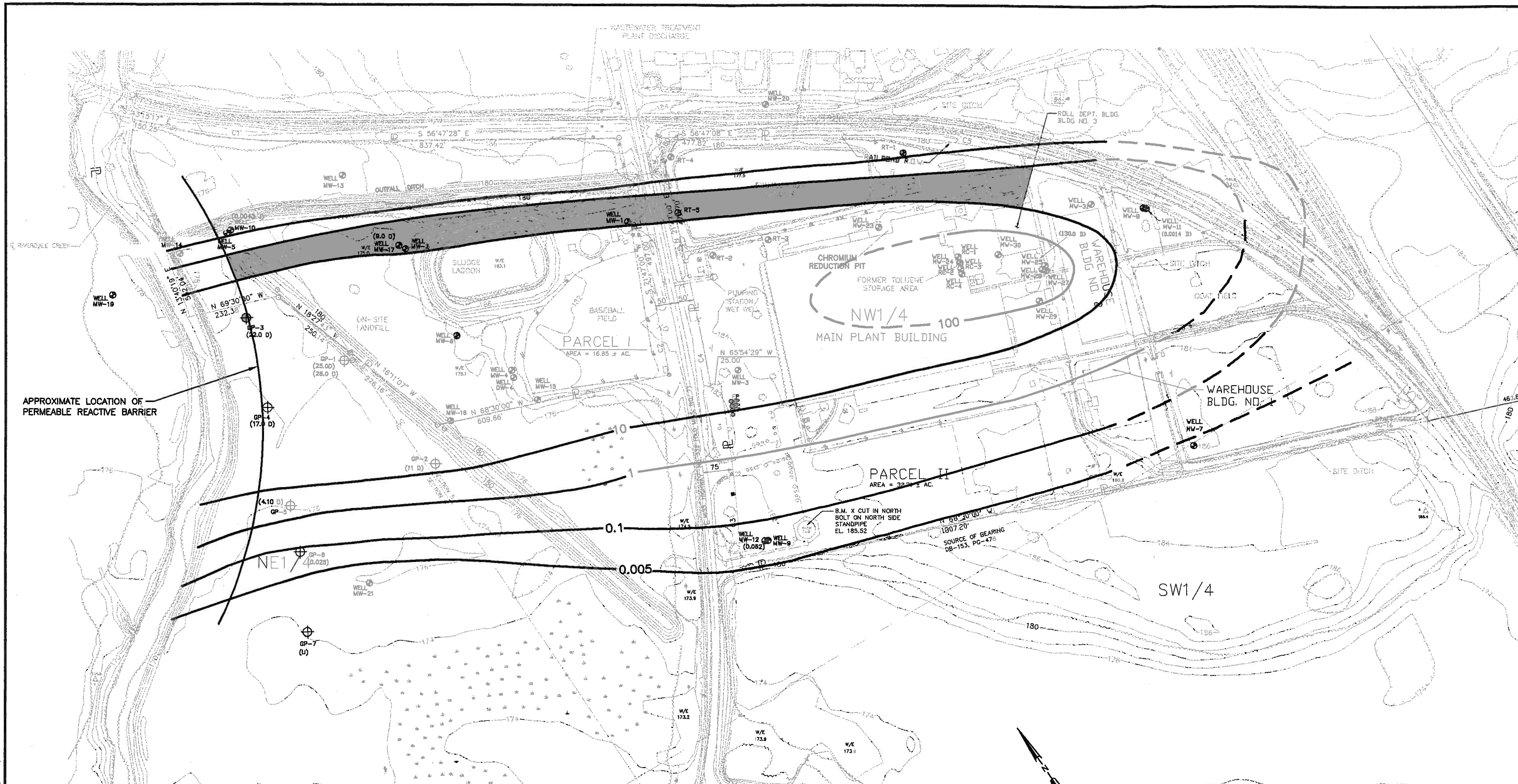
SCALE 250 0 250 500 FEET

FIGURE 3-1
PROJECTED TRICHLOROETHENE CONCENTRATION MAP OF THE UPPER PORTION OF THE UPPER MOST AQUIFER
GRENADA MANUFACTURING, LLC PLANT
GRENADA, MISSISSIPPI
19071.001 05/01

BROWN AND CALDWELL Nashville, Tennessee

DRAWING NO.: 19071-23B DATE: 05/18/01 PLOT SCALE 1=250

DRAWING NO.: 19071-23A DATE: 05/11/01 PLOT SCALE 1=250



LEGEND

- Monitoring Well
- Geoprobe Location
- (0.0043) Trichloroethene Concentration in mg/L
- (U) Non-Detection
- (J) Estimated Concentration
- (D) Diluted Sample
- Concentration Contour, mg/L (Dashed where inferred) Minimum contour is equivalent to the USEPA MCL.

NOTE: DNAPL was observed in monitoring well MW-28.

SOURCE: MAP PREPARED BY ALMON ASSOCIATES, 1993. WELL LOCATIONS SHOWN ARE APPROXIMATE.

SCALE 250 0 250 500 FEET

FIGURE 3-2
OCTOBER 2000 TRICHLOROETHENE CONCENTRATION MAP OF THE LOWER PORTION OF THE UPPER MOST AQUIFER
GRENADA MANUFACTURING, LLC PLANT
GRENADA, MISSISSIPPI
19071.001 05/01

BROWN AND CALDWELL Nashville, Tennessee

historical high groundwater elevation down into the top of the underlying aquitard. Historically, the measured high groundwater elevation has been observed at approximately 10 feet below the ground surface. Based upon geologic data obtained during the geotechnical investigation, the top of the aquitard lies roughly 50 feet below the ground surface along the alignment of the wall. This represents a typical wall height of approximately 40 feet. To help ensure adequate capture of the groundwater plumes, the wall will be tied into the aquitard a minimum of 1 foot and will extend to at least 1 foot above the measured high groundwater elevation.

The thickness of the permeable reactive barrier is based on the results of the bench-scale treatability study, the groundwater velocity in this vicinity of the Site, and the characteristics of the groundwater plumes. As such, the thickness of the granular iron may vary over the length of the wall to accommodate heterogeneity in the flow characteristics and the existing constituent concentrations. Based on a preliminary review of Site data, EnviroMetal Technologies estimates that the necessary granular iron thickness will vary between 1.5 feet and 2.0 feet (assuming 100 percent iron). This varying thickness allows sufficient residence time to reduce groundwater constituent concentrations to below the target goals for the Site (i.e., potentially as low as MCLs). The wall will consist of a sand and granular iron mixture with an average hydraulic conductivity greater than that of the surrounding soil. Typical excavation equipment will require a trench width of about 2.5 feet, which is greater than the thickness required for the granular iron. Therefore, the sand will fill the additional space. To accommodate the variation in the needed thickness of granular iron, the proportions of iron to sand will vary. For instance, where 1.5 feet of granular iron is needed, the mixture will consist of about 60 percent iron and 40 percent sand. The mixture will change to 80 percent iron and 20 percent sand in the section of the wall where 2 feet of granular iron is needed.

Because the October 2000 groundwater data suggests that VOCs are flowing to Riverdale Creek, it is desirable to place the permeable reactive barrier as close as possible to the creek and intercept as much impacted groundwater as is practicable. However, there are technical factors that require the location of the wall to be a reasonable distance from the creek. As indicated in Section 2.2, mineral precipitation is a potential issue for this technology. The precipitation typically occurs on the upgradient side of the permeable reactive barrier. However, existing data shows that this does not significantly impact the effectiveness of the granular iron. Additionally, due to changes in Eh and pH as a result of treatment, precipitation may occur in Riverdale Creek. Therefore, the wall will be placed a reasonable distance from the creek to allow the treated groundwater to equilibrate with the environment prior to discharging into the creek. Additional factors for locating the wall some distance away from the creek include creek bank stability and available work area for the contractor. The selected wall location is roughly parallel to Riverdale Creek, ranging in distance from about 66 feet to 118 feet to the east.

3.2 WALL CONSTRUCTION

Due to the depth required for placement of the permeable reactive barrier and the relatively shallow groundwater surface elevation, the anticipated wall construction method will be the use of a slurry trench method. Of course, the wall must allow groundwater to flow through it after completion. Therefore, biodegradable slurry will be used to install the trench. This slurry (typically composed of guar gum) will degrade within a couple of days thereby allowing normal groundwater flow. This brief temporary period of blocked flow has been estimated to be insufficient to significantly impact the normal groundwater flow patterns. Additionally, studies have shown that while the biopolymer slows VOC degradation rates over the short-term, this impact is not significant in the long-term.

Due to the minimal topographic relief across the Site, the general project area is typically wet and cannot support heavy construction equipment. In addition, a minimum working hydraulic head will likely need to be placed on the trench to keep the walls from collapsing into the trench (see Section 2.3). Because of this, a work platform will likely be required as part of construction. In general, this work platform will likely consist of the placement of a geotextile over the existing ground surface followed by the placement of structural fill material of sufficient thickness and gradation to support the construction equipment and method. Because the construction method is specific to a contractor, the exact dimensions and composition of the work platform will be the responsibility of the selected contractor, while meeting minimum design criteria.

Construction of the wall has been designed to minimize disturbance of the surrounding area. Once the sand and granular iron mix has been placed, the trench will be backfilled to match the existing surrounding contours and the vegetative cover will be restored. The access road and work platform may be removed (if required) and materials properly disposed. As such, there will be no net fill within the project area or net fill will be limited to the work platform and access road if they are allowed to remain in place. With the exception of piezometers and monitoring wells in the vicinity, no aboveground structures or items will remain at the completion of the project.

Currently, a small component of the upper portion of the aquifer discharges into the stormwater ditch near the north end of the project area. To address this groundwater component, the bottom of the ditch will be raised such that groundwater flow will shift to the west and more closely reflect the patterns in the lower portion of the aquifer. To capture this projected redirection of constituent flow, the permeable reactive barrier will be installed across the ditch to a distance of roughly 100 feet north of the north ditch bank. Separation of the surface water flowing in the ditch and the groundwater flowing through the wall must be made to avoid mixing the two flows and potentially allowing the groundwater to circumvent the wall or to allow unnecessary surface water flow through the wall. To accomplish this, a geocomposite clay layer (GCL) will be placed along a portion of the ditch extending across the wall. The GCL will extend up the sides of the ditch a sufficient distance to separate flows. A thin layer of soil overlain by geotextile and crushed stone (rip rap) will then be placed over the GCL to protect it from scour.

The sand and granular iron mixture will be placed through the slurry into the trench using a tremie method whereby the mixture is placed at the bottom of the trench and displaces the slurry. The sand and granular iron will be mixed aboveground to the appropriate proportions and then placed into the trench. Experience has shown that, if proper care is taken by the contractor, separation of the sand and iron will not occur to a significant degree. To ensure that the vertical extent of groundwater is intercepted by the wall, the permeable reactive barrier will be placed at least 1 foot into the aquitard that exists at the base of the aquifer. Quality assurance requirements will be included with the technical specifications for wall construction to verify that this tie-in has been achieved.

3.3 TRENCH STABILITY

A stability analysis was conducted for slurry trench construction. Input data for the analysis included physical and engineering properties for the soil formations into which the trench will be cut (see Section 2.1). Additional input data include the assumption that the slurry density used in the construction of the trench would be 64 pounds/cubic foot. The analysis was performed for a trench of infinite length (as opposed to alternating panels of limited length), which is a conservative assumption. The available data in the area near the proposed trench location indicate groundwater has been encountered between 10 and 15 feet below the ground surface. Based on the ground surface elevations and the elevations of the surface of the marl stratum interpreted from the field data, trench depths are anticipated to range from approximately 47 to 60 feet.

For the trench stability analysis, the soil at the sides and bottom of the trench are considered to be in a Rankine state of elastic equilibrium. Upon excavation of the trench and placement of the slurry, the surrounding soil is considered to be in an active Rankine state. Based on the Rankine method of analysis and the trench configurations described above, factors of safety were calculated for trenching conditions in which the depth to groundwater varied from 5 to 10 feet. The stability analysis indicates that for the conditions anticipated during wall construction, the initial factors of safety against trench instability are approximately 1.05 for a trench depth of 60 feet below the existing ground surface and with a work platform height of 3 feet. The calculated factor of safety falls below 1.0 for a trench depth greater than 60 feet and depth to groundwater of less than or equal to 10 feet. The calculated factors of safety would only be present during the trench excavation prior to backfilling the trench. The factor of safety for the backfilled trench would rise to approximate the existing conditions at the Site. The expected consequences of a trench sidewall failure during excavation would be limited to loss of slurry into the weaker soil zones, sloughing of the trench walls resulting in a widening of the trench, and potential localized settlement or subsidence of the ground surface in the area of the trench. A panel method of construction (i.e., sequential installation of wall sections with limited length) may be appropriate based on these conditions (rather than a method of continuous trenching). This method would improve stability and limit the extent of rework required if a section of trench required reworking. A copy of the trench stability calculations showing input parameters and analysis results are included in Appendix A.

The calculated factors of safety are due, in part, to the presence of low-strength soil layers interspersed within the sand. The lowest laboratory-determined strength values for these low-strength layers were used in the trench stability calculations. Use of these lowest strength values is a conservative assumption. The lowest strength values determined were from a sample collected 30.0 to 32.0 feet below the ground surface that had a saturated unit weight of approximately 128 pounds per cubic foot, an effective angle of internal friction (phi) of 0.6 degrees, and an effective cohesion of 0.09 kips per square foot (KSF). These laboratory-determined strength values are lower than would reasonably be expected from a soil located 30 feet below the ground surface, and likely do not accurately reflect the in-situ properties of the soil. As a result, prior to construction the contractor will be required to conduct additional sample collection and analysis to further define the in-situ properties of the soil. These additional data will be used to re-evaluate trench stability and will be used to determine the methods and configuration of construction of the trench. The information collected during the geotechnical investigation and the trench stability analysis will be provided to the prospective contractors during the bidding process. The trench contractor will be required to employ methods that account for the soil characteristics and for successful construction of the trench.

During construction of the trench, the contractor will be required to maintain the level of the slurry to within 1 foot of the ground (or work platform) surface and at least 9 feet above the top of groundwater in sections of the trench with final depths of 60 feet or less. The biopolymer slurry proposed for the trench construction loses viscosity in a relatively short time period (e.g., 1 to 2 days) if additives are not employed to prevent this breakdown. In addition, increases in temperature (e.g., summer construction) also increase the rate at which the biopolymer loses viscosity. To address these factors, the contractor will be required to maintain sufficient slurry viscosity and to have sufficient reserve quantities of slurry to maintain a stable trench during construction. If the groundwater levels encountered during construction do not meet the anticipated conditions, then the stability of the trench will be re-evaluated. A determination of the necessary mitigation measures (i.e., dewatering, raised work platform, slurry formula alteration, etc.) will then be performed.

3.4 SURFACE WATER DRAINAGE

As stated previously, a small component of groundwater flow currently discharges to the stormwater ditch on the north side of the project area. To address this flow component, the bottom of a portion of the ditch will be filled to above the historical high groundwater elevation such that groundwater flow does not intercept the bottom of the ditch. This activity will cause the groundwater flow in the immediate area to turn west toward Riverdale Creek similar to the flow patterns in the lower portion of the aquifer. Because a portion of the ditch will be filled, the surface water flow characteristics of the ditch were evaluated such that any impacts from the filling tasks could be addressed. The result of this evaluation is the placement of rip rap along the bottom of that portion of the ditch that will be disturbed and regraded as part of this interim measure.

Flow in the ditch comes from three sources: flow through the existing culvert under the highway that serves an area east of the highway, the NPDES outfall discharge, and incident and local runoff. The largest component of flow is that from the culvert during a significant storm event. This flow is limited by the size of the culvert, which will not be impacted by this interim measure. Therefore, none of the flow components will change as a result of this interim measure. Based on this fact, protection of the regraded ditch was evaluated based on the estimated flows. Flow calculations are included in Appendix A. The results of this evaluation indicate that rip rap will be placed along the entire section of the ditch to be disturbed as part of construction activities. The portion of the ditch from the top of the permeable reactive barrier upstream to the limits of disturbance will be backfilled such that the new slope will be approximately 0.0033 feet/foot (or 0.33 percent). However, the section from the top of the wall to the discharge point into Riverdale Creek will be somewhat steeper at 0.015 feet/foot (or 1.5 percent). Based on these slopes, BC determined that rip rap will be necessary to address erosion forces. Rip rap placed in the ditch will be underlain by a geotextile to separate the coarse fraction (rip rap) from the underlying soil.

The area of the ditch to be improved is divided into two sections, upstream and downstream of the permeable reactive barrier. Stormwater flow calculations were performed using the Rational Method to estimate both the amount of stormwater runoff expected during a design storm and the material necessary to protect the surfaces of the drainage ditch from erosion in each of these sections. For purposes of design, a storm with a recurrence of 25 years (i.e., a 25-year, 30-minute storm event) was used to define the drainage ditch improvements. Based on the amount of anticipated runoff and the channel geometry, a peak flow of 61 cubic feet per second (cfs) was calculated. Again using channel geometry, maximum depths of flow for each section were estimated at 3 feet upstream of the wall and 2.5 feet downstream of the wall. The amount of ditch lining and protection was also determined. National Stone Association (NSA) R-3 designated rip rap (an average size of 3 inches) is required in both sections of the ditch at a minimum thickness of 8 inches (12 inches will be utilized). The rip rap lining has been extended one foot above the calculated depth of flow to provide freeboard.

During construction activities in the ditch, the contractor will be required to divert the flow in the ditch around the disturbed area into Riverdale Creek. The contractor will likely construct some type of temporary dam or other diversion structure near the upstream limits of work in the ditch. This will allow approximately 400 feet of the eastern portion of the ditch to act as a temporary storage unit while water is pumped around the construction area and into the creek. In addition, the contractor will likely construct a "bridge" across the ditch along the wall alignment to allow trench equipment to cross the ditch. This will create a temporary ponded area between the dam and the "bridge" that the contractor will be required to maintain in a proper working condition (i.e., relatively dry). Finally, the section of ditch between the "bridge" and the discharge point into Riverdale Creek will be filled, graded, and covered with rip rap. During construction activities, a rock filter dam will be constructed across the base of the ditch to filter sediment from stormwater runoff that passes through this disturbed section of the ditch prior to discharging into the creek.

The intent for this project is that construction activities occur during the drier months of the year so that stormwater runoff is likely to cause potential problems. However, due to the uncertainty surrounding precipitation events, the contractor will be required to minimize the time during which the outfall ditch is blocked. In addition, the contractor will be required to maintain the water level in the ditch at a maximum depth equal to the invert elevation on the culvert under the highway. The contractor may also be required to allow the NPDES discharge from the facility treatment plant to fill a portion of the blocked ditch and then pump from the collected water at a rate equal to the NPDES discharge flow rate. This is intended to reduce the impact to the flow in Riverdale Creek. Pumping of water collected in the outfall ditch will be described in more detail in the technical specifications.

3.5 ENGINEERING DESIGN

Utilizing the various design criteria described in this section, along with the results of the pre-design efforts described in Section 2.0, BC prepared detailed engineering plans and specifications. Because some critical information is still being developed (specifically, completion of the bench-scale treatability study), the plans and specifications cannot yet be completed. When complete, these plans and specifications will be suitable for prospective contractors to bid on the project and for the selected contractor to construct the permeable reactive barrier and related components. A copy of the engineering plans completed to date are included as Appendix B. The technical specifications are still in development. A copy of the outline showing the anticipated specifications to be included in the bid package is included as Appendix C.

4.0 PLAN FOR SATISFYING PERMIT REQUIREMENTS

Interim measure activities will be performed in accordance with the requirements of applicable federal, state, and local laws and regulations. Implementation of the interim measure is not expected to require the crossing of any streams, railroads, or public roads. Local construction permits and/or approvals associated with the daily construction activities will be the responsibility of the selected contractor and will be discussed and coordinated with local authorities. A discussion of the regulatory issues identified to date is provided below.

4.1 CONSTRUCTION IN WETLANDS AND/OR FLOODPLAIN

Construction of the interim measure will occur in an area adjacent to Riverdale Creek. In addition to construction of the permeable reactive barrier, an access road and work platform will likely be necessary. The construction is expected to be relatively brief (i.e., two to three months duration) and will be temporary (i.e., no structures will remain after construction). In addition, components of the interim measure will be below grade and there will be no net fill associated with this project. Possible exceptions include the access road and work platform (if they are allowed to remain in place) and the stormwater ditch where roughly half of the ditch will be regraded to include approximately 2 feet of clean backfill above the wall. None of the anticipated activities are expected to drain the area, as standing water appears to result from ponded surface water and does not intersect the aquifer or any surface water body or result from groundwater discharge to the surface.

It is not clear whether any of these limited activities will be performed in a wetlands area. A formal determination has not been made whether this area would be classified as jurisdictional wetlands regulated by the United States Army Corps of Engineers (USACE). An interpretation of the National Wetlands Inventory map of the area suggests that a portion of the project area may lie within a wetlands area. However, these maps are prepared primarily by stereoscopic analysis of high altitude aerial photographs and do not necessarily reflect jurisdictional wetland boundaries. Mississippi wetlands regulations appear to be inapplicable to potential wetlands at the Site, as they mostly pertain to coastal wetlands. Therefore, an application for a Jurisdictional Determination has been prepared and submitted to the USACE office in Vicksburg, Mississippi. The request seeks the opinion of the USACE as to the presence of wetlands within the project area and, if wetlands are present, identification of applicable permit requirements (if any). If permits are required as part of this project, the applicable permit applications will be submitted and approvals received prior to beginning construction activities.

The existing FEMA map for the stretch of Riverdale Creek adjacent to the Site indicates that the project area is within the 100-year floodplain. The Jurisdictional Determination request submitted to the USACE also requests that the USACE provide information regarding applicable permit requirements associated with the interim measure. As with the wetlands determination, if permits are required for construction within a floodplain, the applicable permit applications will be submitted and approvals received prior to beginning construction activities.

4.2 EROSION CONTROLS

Construction of this interim measure will largely follow a linear pattern with activities focused around the alignment of the wall and the access road. Because the location of the access road will be the responsibility of the contractor, the total area disturbed by construction activities is unknown. BC contacted a local official regarding erosion control requirements and we were informed that preparation and transmittal of an erosion and sedimentation control plan is not necessary. The contact stated that there are no city or county requirements for submittal of an erosion control plan. However, the selected contractor will be required to implement and maintain erosion controls as a part of construction. The vicinity in and around the limits of construction has minimal topographic relief (with the exception of the stormwater ditch). Therefore, temporary erosion controls will take the form of silt fence and/or hay bales surrounding the disturbed area. Within the ditch, erosion controls will include diversion of stormwater, the use of silt fence and/or hay bales, and the use of a rock filter berm. At the completion of the construction activities, the contractor will be required to vegetate disturbed areas using vegetation similar to that existing in the project area.

Part of the construction activities will include the filling and grading of the western portion of the stormwater outfall ditch. To permanently protect the backfilled area, rip rap will be placed in the ditch along the disturbed portion. The graded length of ditch from the permeable reactive barrier upstream to the limits of grading will have minimal topographic relief and, therefore, requires relatively small crushed stone lining for protection. However, the segment from the wall to the discharge point into the creek will be somewhat steeper and a larger stone has been designated for this length of ditch. Details regarding the placement of the rip rap in the ditch are shown on the engineering drawings included in Appendix B.

4.3 TREATMENT AND/OR DISPOSAL OF EXCAVATED SOIL AND SLURRY

Installation of the permeable reactive barrier will require the excavation of roughly 5,600 cubic yards of soil. A portion of this soil will be impacted by the groundwater that is to be treated by this wall. Based on existing data, it is likely that the impacted soil will be nonhazardous. However, it is also possible that constituent concentrations may be high enough that disposal at a local municipal landfill will not be feasible without some pretreatment. Due to the mixing inherent in the slurry trench construction method, the soil above the groundwater surface may be mixed with the impacted soil from below the groundwater surface. As such, the excavated soil will require treatment and/or disposal as part of these construction activities. In addition, once the slurry wall is complete, excess slurry will exist that will also need to be addressed. This excess slurry will likely be mixed with and handled in the same manner as the excavated soil.

BC has evaluated disposal and on-site treatment options for handling of the impacted material. This evaluation included a review of applicable RCRA regulations, the cost of various options, and the timing involved with the various options. Various treatment options exist that are likely applicable to the conditions at the Site, including low temperature thermal desorption, chemical oxidation (e.g., using sodium or potassium permanganate, ozone, or Fenton's reagent), and biodegradation. Issues relating to treatment that were considered include residual chemicals and byproducts in the treated soil, the need to drain the soil regardless of whether treatment or disposal is selected, and the final disposition of the soil.

Low temperature thermal desorption is likely not the best treatment technology for the types of soil to be encountered during this project. The soil is comprised of a large portion of small size particles (i.e., fine sand and silt), which adversely impacts the effectiveness of the process. Biodegradation would also not be the best selection for this project due to the longer time required to reach treatment goals and the reduced control over the treatment process. The use of ozone or Fenton's reagent may be more cumbersome, but the process leaves fewer residuals than use of permanganate and, therefore, may be more attractive. The excavated soil will likely have a high water content and, therefore, will need to be drained before treatment or hauling for off-site disposal. This has been addressed by requiring the selected contractor to drain the water into the slurry trench or collect and use drained water from the excavated soil as make-up water for slurry production.

On-site soil treatment interim measures have been implemented at this Site in the past. The On-Site Landfill Area was previously treated using ex-situ soil vapor extraction. The purpose of that interim measure was to remove constituent mass of TCE. Although other VOCs were present, TCE was the only constituent where measured concentrations exceeded the calculated interim target cleanup level. The interim target goal for TCE was calculated to be 7.8 mg/kg. Preliminary indications are that the soil to be excavated during installation of the permeable reactive barrier will exhibit concentrations below this target cleanup level. The selected contractor will be required to characterize the excavated soil as part of this interim measure. Excavated soil will be placed onto a plastic liner and allowed to gravity drain into the slurry trench or into temporary sumps where it can be used as slurry make-up water. Once the soil has drained adequately, samples will be collected and analyzed for characterization of the soil. If the soil concentrations exceed the action levels, the soil will be treated and/or disposed of off-site at an appropriate facility. However, if concentrations are below the interim target cleanup level, excavated soil will be temporarily stockpiled on site for use as clean backfill.

5.0 INTERIM MEASURE SCHEDULE

A preliminary schedule for implementation of the groundwater interim measure at the Site is currently in development. The actual schedule is dependent on the following efforts:

- USEPA Review – The time required for the USEPA to complete its review of this document and any others identified by the agencies as requiring approval prior to implementation will directly impact the implementation schedule.

- Permitting Process – Grenada Mfg. has submitted a request for determination of the need for permits associated with implementation of the interim measure. If necessary, the appropriate permit applications will then be filed for approval. Construction of the interim measure will not begin until the required permit approvals have been received.

- Access Agreements – Arvin Meritor is currently in negotiations with the owner of the property along Riverdale Creek not owned by Grenada Mfg. Construction of the interim measure will likely not be allowed to begin until the appropriate agreements are in place.

- Identify and Select Contractor – Once the efforts described above are complete (or at least substantially complete), Arvin Meritor will identify and screen prospective contractors, request and review bids, and select a contractor. This effort is not anticipated to require a significant amount of time and will likely be performed while awaiting completion of the other tasks described above.

Due to conditions associated with the area of the Site where the permeable reactive barrier will be constructed, Grenada Mfg. prefers to perform construction during dry weather months (i.e., July through October). At this time, BC anticipates that the entire construction phase will require only approximately two to three months to complete. However, a more detailed construction schedule will be established by the selected contractor as part of its bid.

6.0 CONSTRUCTION QUALITY ASSURANCE

Installation of the permeable reactive barrier will be conducted in accordance with a Construction Quality Assurance Plan (CQAP). The technical specifications for the project will define the quality control requirements for the selected contractor. The CQAP will address the quality assurance requirements for monitoring and documenting conformance with the design plans and specifications. A CQAP has not yet been prepared for this project because a project delivery method has not yet been selected. At this time, Arvin Meritor has not determined whether a contractor will be identified, selected, and retained directly by Arvin Meritor or if an engineering firm will be retained to provide turnkey construction services. If Arvin Meritor elects to retain the contractor, it is likely that a single contractor will be selected as the prime contractor and subcontractors (e.g., surveyor, landscaper, driller) may be used. If a turnkey approach is utilized, the project may be separated into smaller contracts by related tasks. Once the project delivery method is identified, a draft CQAP will be prepared as an appendix to this report (Appendix D) and will be transmitted to the USEPA for review and approval.

Prospective contractors will be pre-qualified before the bid solicitation process begins. As such, only qualified contractors will be asked to submit bids for the construction. As part of the bid solicitation process, a Pre-Bid Meeting will be held on Site to enable qualified contractors to view the Site and be briefed on issues related to the Site and the project. To the extent possible, the project will be bid as one or more lump sum contracts depending upon the project delivery method. Review of bids and selection of contractors will require approximately two weeks followed by contract negotiations. Prior to initial mobilization by the selected contractor, a Pre-Construction Meeting will be conducted on Site.

Construction activities are expected to be continuous from the initial mobilization by the contractor through completion and demobilization from the Site. The contractor(s) will be responsible for procurement of all equipment, materials, and labor. Submittals are required by the technical specifications to be approved prior to use or implementation of the associated equipment or materials. The prime contractor or the turnkey firm will be responsible for health and safety of all on-site personnel. Prior to demobilization, a Final Construction Inspection will be conducted and preparation of a Final Construction Report will begin. Operation and maintenance in accordance with the Performance Monitoring Plan (see Section 7.0) will also begin after demobilization.

7.0 PERFORMANCE MONITORING

The interim measure discussed in this Design Basis Report was selected, in part, due to its low operation and maintenance requirements. The installation anticipated for this Site is expected to require only groundwater monitoring for long-term operation and maintenance tasks. This monitoring program will be established based on the results of a bench-scale treatability study using groundwater collected from the Site and granular iron likely to be used in the permeable reactive barrier. This treatability study is currently still in progress (see Section 2.0). As such, final information regarding wall thickness and other properties is not available. Once all of the various design parameters have been established, a Performance Monitoring Plan will be prepared as an appendix to this report (Appendix E) and transmitted to the USEPA for review and approval. This Plan will outline the sampling parameters and frequency, as well as the reporting requirements for the interim measure.

In general, the primary approach for monitoring the effectiveness of the permeable reactive barrier will be through the use of monitoring wells installed as part of constructing the wall. Typically, these wells are installed perpendicular to the wall in a line of three or four depending, in part, on wall thickness. Due to the hydrogeology in this area of the Site, it is also possible that the piezometers will be installed such that the upper and lower portions of the aquifer can be monitored separately using nested pairs of monitoring wells. The number of "lines of piezometers" to be used to monitor the wall will depend, in part, on the variability of the wall thickness and the observed concentrations for the key constituents of concern. Based on the 1,200-foot length of wall, approximately 3 lines are anticipated. Preliminary well locations are shown on the engineering drawings (Appendix B; sheets 03 and 04). Where possible, existing monitoring wells will be utilized to monitor the wall (particularly the upgradient side).

To monitor the effectiveness of the wall, groundwater samples will be analyzed primarily for select volatile constituents of concern (e.g., TCE and toluene). Because SVOCs and metals are less of a concern in this area of the Site, these parameters will not be included in the more frequent monitoring program. Instead, SVOCs and metals will be included in a less frequent monitoring program that will encompass a larger area of the Site.

APPENDIX A

DESIGN CALCULATIONS

- Geotechnical Testing Results
- Trench Stability Calculations
- Outfall Ditch Flow Calculations

GEOTECHNICAL TESTING RESULTS

QORE

PROPERTY SCIENCES

May 2, 2001

Brown & Caldwell Consultants
501 Great Circle Road, Suite 150
Nashville, Tennessee 37228

Attention: Mr. Mike Freehling

Subject: Soil Testing
QORE Job No. 22258, Report No. 191146

Gentlemen:

QORE, Inc. has completed the laboratory testing on the soil samples sent by your office. The following tests were performed:

- Natural Moisture Content (ASTM D-2216)
- Atterberg Limits (ASTM D-4318)
- Unit Weight
- UU with Pore Pressure (ASTM D-2850)
- Direct Shear (ASTM D-3080)

QORE, Inc. performs soil tests in general accordance with the applicable American Society for Testing and Materials (ASTM) or AASHTO procedures. These procedures are generally recognized as the basis for uniformity and consistency of test results in the geotechnical engineering profession. All the work is supervised by a qualified engineer. Attached are test results for your review.

QORE, Inc. appreciates the opportunity to provide these laboratory services. Please contact us if you have any questions concerning this report or if we may be of further service.

Respectfully submitted,
QORE, INC.

Ashok K. Mangla, B.E. (Civil)
Geotechnical Laboratory Manager
Member ASTM D-18, D-35

C. Scott Fletcher, P.E.
Chief Geotechnical Engineer
Reg. Ga. 16170

AKM/CSF/jk
Attachment

QORE™ PROPERTY SCIENCES

TRIAXIAL SHEAR TEST REPORT
(ASTM D 2850)

JOB NAME:	Arvin - Meritor Site						
JOB NO.:	22258	REPORT NO. :	191146	REVIEWED BY :		DATE	4/24/01
BORING / PIT NO. :	B-1	DEPTH / ELEV. :	30'-32'	SAMPLE NO . :	-	TYPE:	UD
SAMPLE LOCATION : -							
SOIL DESCRIPTION : *Gray silty fine to medium sand .*							
LIQUID LIMIT, % :	N.P.	PLASTICITY INDEX , % :	N.P.	FINES, % :	23	G_s :	2.67

SPECIMEN PROPERTIES

		INITIAL				AFTER CONSOLIDATION		
SPECIMEN NO.		1	2	3		1	2	3
DIAMETER , INCHES	D_o	2.88	-	-	D_c	2.87	-	-
HEIGHT , INCHES	H_o	5.90	-	-	H_c	5.89	-	-
WATER CONTENT, %	W_o	21.3	-	-	W_c	21.4	-	-
DRY DENSITY, PCF	γ_{dryo}	105.0	-	-	γ_{dryc}	105.9	-	-
SATURATION ,%	S_o	97.5	-	-	S_c	100	-	-
VOID RATIO	e_o	0.583	-	-	e_c	0.571	-	-

TEST TYPE : UU / PORE PRESSURE

TEST PARAMETERS

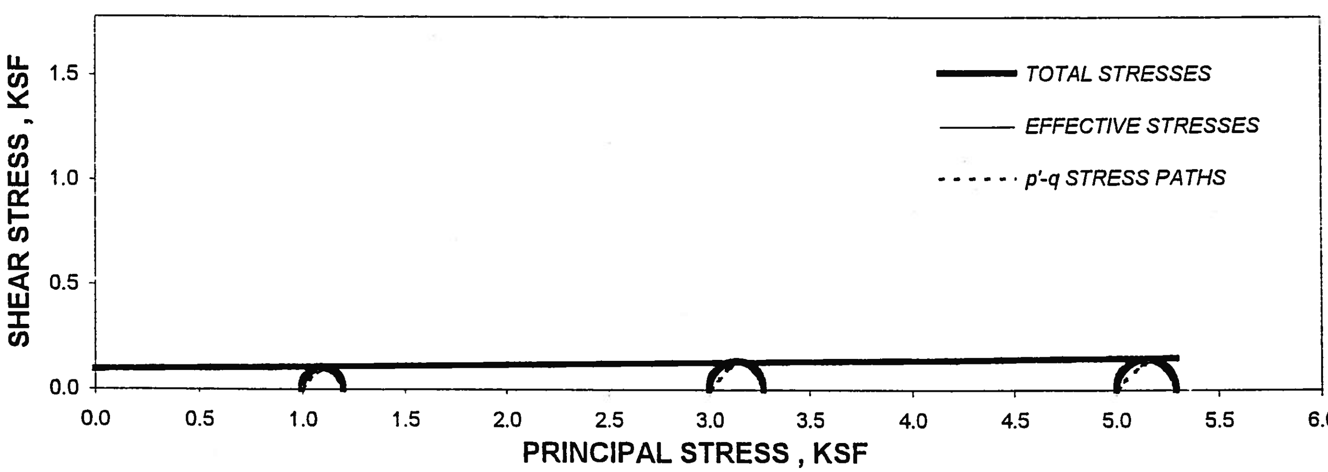
SPECIMEN NO.		1	2	3
BACK PRESSURE, KSF	U_o	1.0	3.0	5.0
CONFINING PRESSURE , KSF	σ_3	1.0	3.0	5.0
MAX. DEVIATOR STRESS ,KSF	σ_1-σ_3	-	-	0.3
ULT. DEVIATOR STRESS , KSF	σ_1-σ_3	-	-	0.2

CONTROLLED
Strain @ 0.5 % per minute

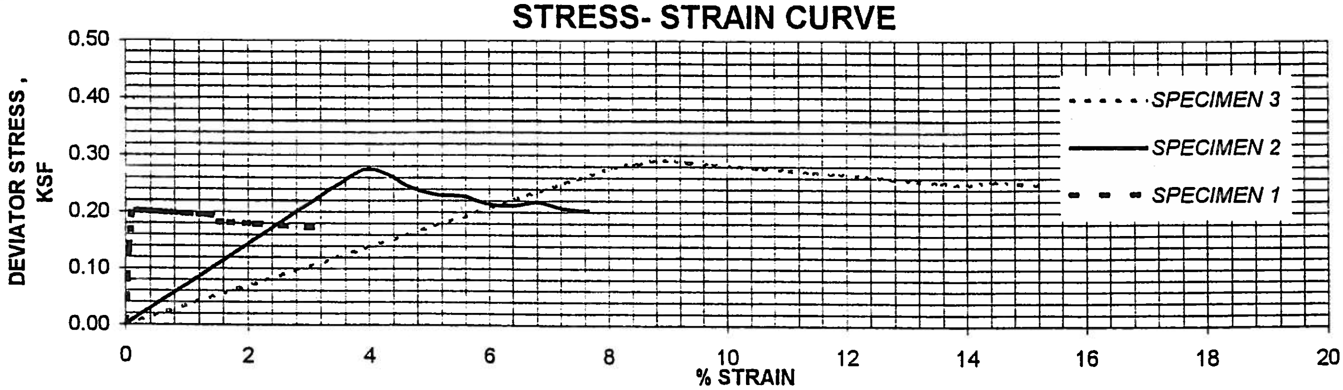
NOTE : *THIS IS A MULTISTAGE TRIAXIAL*

SHEAR STRENGTH PARAMETERS	TOTAL	EFFECTIVE
	COHESION , C (KSF) : **0.09**	COHESION , C' (KSF) : **0.09**
	ANGLE OF INTER. FRICTION, Φ(DEGREES) : **0.6**	ANGLE OF INTER. FRICTION, Φ' (DEGREES) : **0.6**

MOHR / p'-q DIAGRAM



STRESS- STRAIN CURVE



TRIAXIAL SHEAR TEST REPORT
(ASTM D 2850)

QORE PROPERTY SCIENCES

JOB NAME:	Arvin - Meritor Site				
JOB NO.: 22258	REPORT NO. : 191146	REVIEWED BY :		DATE	4/24/01
BORING / PIT NO. : B-2	DEPTH / ELEV. : 33.5'-35.5'	SAMPLE NO . :	-	TYPE:	UD
SAMPLE LOCATION : -					
SOIL DESCRIPTION : *Gray fine to medium sand .*					
LIQUID LIMIT, % : N.P.	PLASTICITY INDEX , % : N.P.	FINES, % :	5	G_s :	2.63

SPECIMEN PROPERTIES								
		INITIAL			AFTER CONSOLIDATION			
SPECIMEN NO.		1	2	3		1	2	3
DIAMETER , INCHES	D_o	2.88	-	-	D_c	2.88	-	-
HEIGHT , INCHES	H_o	5.60	-	-	H_c	5.59	-	-
WATER CONTENT, %	W_o	24.3	-	-	W_c	27.0	-	-
DRY DENSITY, PCF	γ_{dryo}	95.7	-	-	γ_{dryc}	96.1	-	-
SATURATION ,%	S_o	89.5	-	-	S_c	100	-	-
VOID RATIO	e_o	0.716	-	-	e_c	0.710	-	-

TEST TYPE : UU / PORE PRESSURE

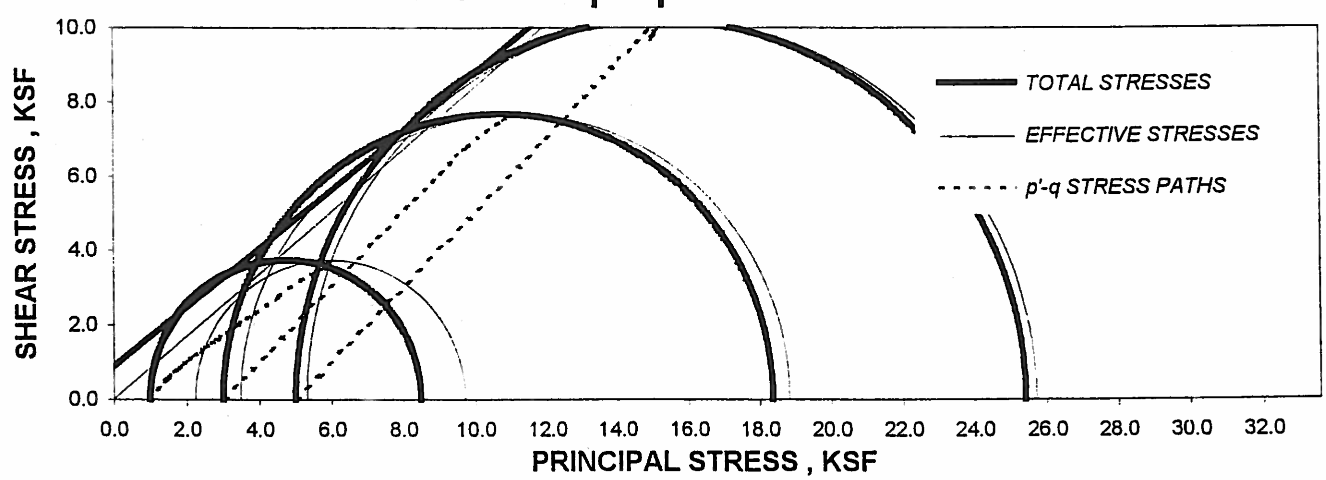
TEST PARAMETERS				
SPECIMEN NO.		1	2	3
BACK PRESSURE, KSF	U_o	0.5	-0.4	-0.9
CONFINING PRESSURE , KSF	σ_3'	1.0	3.0	5.0
MAX. DEVIATOR STRESS ,KSF	$\sigma_1-\sigma_3$	-	-	20.4
ULT. DEVIATOR STRESS , KSF	$\sigma_1-\sigma_3$	-	-	19.4

CONTROLLED
Strain @ 0.5 % per minute

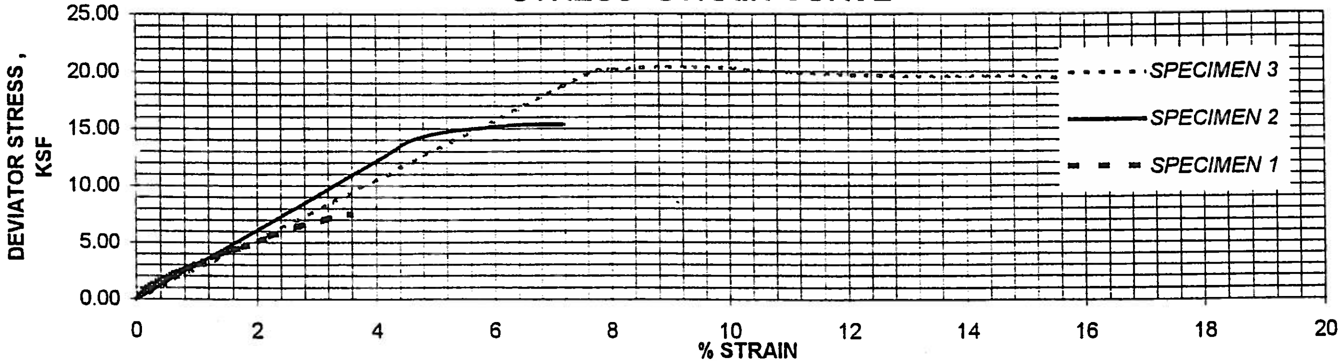
NOTE : *THIS IS A MULTISTAGE TRIAXIAL*

SHEAR STRENGTH PARAMETERS	TOTAL		EFFECTIVE	
	COHESION , C (KSF) :	**0.88**	COHESION , C' (KSF) :	**0.00**
	ANGLE OF INTER. FRICTION, Φ(DEGREES) :	**38.3**	ANGLE OF INTER. FRICTION, Φ' (DEGREES) :	**40.0**

MOHR / p'-q DIAGRAM



STRESS- STRAIN CURVE



TRIAXIAL SHEAR TEST REPORT
(ASTM D 2850)

QORE PROPERTY SCIENCES

JOB NAME:	Arvin - Meritor Site						
JOB NO.:	22258	REPORT NO. :	191146	REVIEWED BY :		DATE	4/24/01
BORING / PIT NO. :	B-3	DEPTH / ELEV. :	26'-28'	SAMPLE NO . :	-	TYPE:	UD
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	*Gray fine to medium sand .*						
LIQUID LIMIT, % :	N.P.	PLASTICITY INDEX , % :	N.P.	FINES, % :	4	G_s :	2.65

SPECIMEN PROPERTIES								
	INITIAL				AFTER CONSOLIDATION			
SPECIMEN NO.		1	2	3		1	2	3
DIAMETER , INCHES	D_o	2.87	-	-	D_c	2.86	-	-
HEIGHT , INCHES	H_o	5.89	-	-	H_c	5.87	-	-
WATER CONTENT, %	W_o	31.5	-	-	W_c	26.8	-	-
DRY DENSITY, PCF	γ_{dryo}	95.7	-	-	γ_{dryc}	96.7	-	-
SATURATION ,%	S_o	114.6	-	-	S_c	100	-	-
VOID RATIO	e_o	0.728	-	-	e_c	0.710	-	-

TEST TYPE : UU / PORE PRESSURE

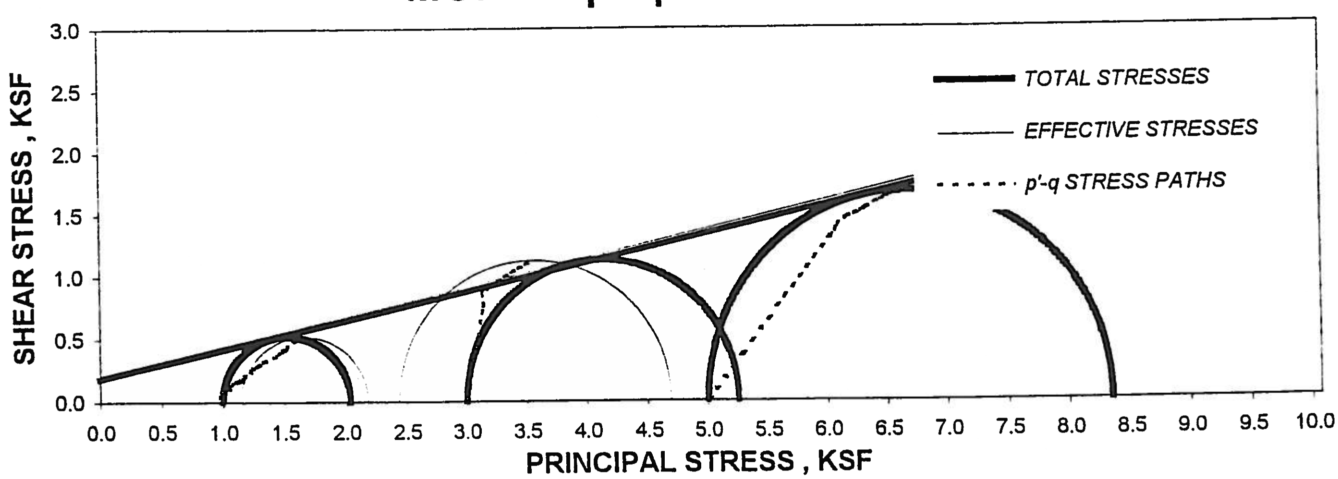
TEST PARAMETERS				
SPECIMEN NO.		1	2	3
BACK PRESSURE, KSF	U_o	0.9	1.8	3.8
CONFINING PRESSURE , KSF	σ_3	1.0	3.0	5.0
MAX. DEVIATOR STRESS ,KSF	σ_1-σ_3	-	-	3.4
ULT. DEVIATOR STRESS , KSF	σ_1-σ_3	-	-	3.4

CONTROLLED
Strain @ 0.5 % per minute

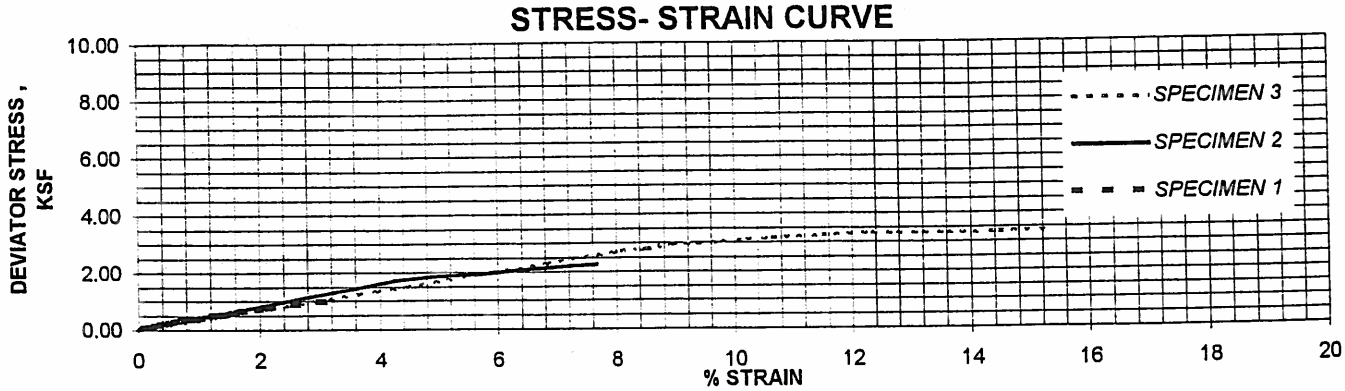
NOTE : *THIS IS A MULTISTAGE TRIAXIAL*

SHEAR STRENGTH PARAMETERS	TOTAL		EFFECTIVE	
	COHESION , C (KSF) :	0.19	COHESION , C' (KSF) :	0.21
	ANGLE OF INTER. FRICTION, Φ(DEGREES) :	13.0	ANGLE OF INTER. FRICTION, Φ' (DEGREES) :	13.1

MOHR / p'-q DIAGRAM



STRESS- STRAIN CURVE



TRIAXIAL SHEAR TEST REPORT
(ASTM D 2850)

QORE™
PROPERTY SCIENCES

JOB NAME:	Arvin - Meritor Site				
IOB NO.:	22258	REPORT NO. : 191146	REVIEWED BY :	DATE	4/24/01
ORING / PIT NO. :	B-4	DEPTH / ELEV. : 26'-28'	SAMPLE NO . : -	TYPE:	UD
SAMPLE LOCATION :	-				
SOIL DESCRIPTION :	*Gray fine to medium sand .*				
IQUID LIMIT, % :	N.P.	PLASTICITY INDEX , % : N.P.	FINES, % : 3	G_s :	2.62

SPECIMEN PROPERTIES								
	INITIAL				AFTER CONSOLIDATION			
PECIMEN NO.		1	2	3		1	2	3
DIAMETER , INCHES	D_o	2.86	-	-	D_c	2.86	-	-
EIGHT , INCHES	H_o	5.94	-	-	H_c	5.93	-	-
WATER CONTENT, %	W_o	18.7	-	-	W_c	17.9	-	-
DRY DENSITY, PCF	γ_{dryo}	110.8	-	-	γ_{dryc}	111.4	-	-
ATURATION ,%	S_o	103.1	-	-	S_c	100	-	-
VOID RATIO	e_o	0.477	-	-	e_c	0.469	-	-

TEST TYPE : UU / PORE PRESSURE

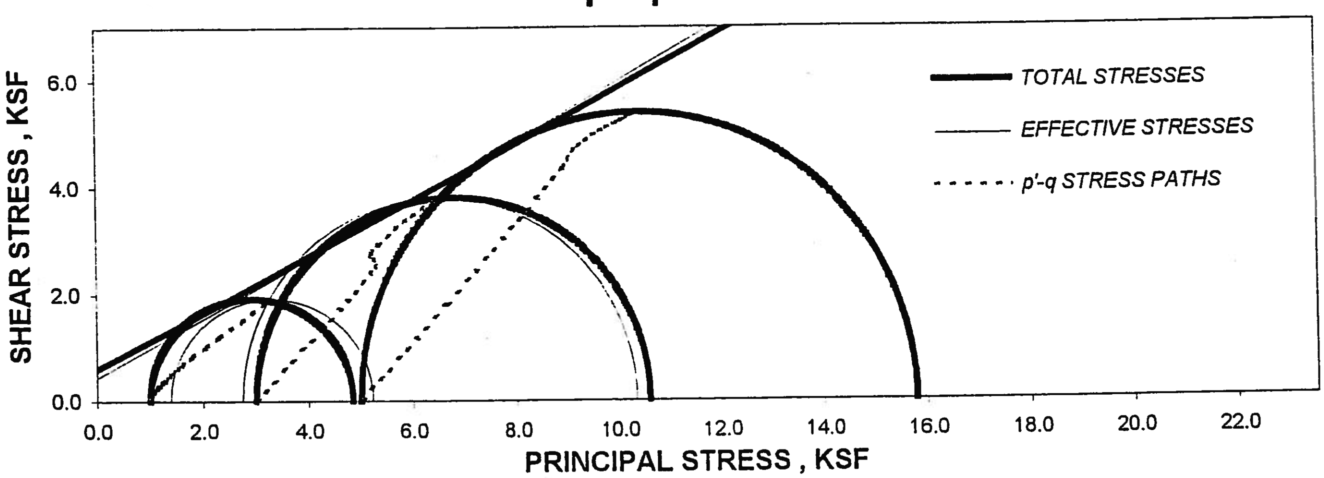
TEST PARAMETERS				
SPECIMEN NO.		1	2	3
BACK PRESSURE, KSF	U_o	0.7	0.8	1.4
CONFINING PRESSURE , KSF	σ_3	1.0	3.0	5.0
MAX. DEVIATOR STRESS ,KSF	σ_1-σ_3	-	-	10.8
ULT. DEVIATOR STRESS , KSF	σ_1-σ_3	-	-	10.8

CONTROLLED
Strain @ 0.5 % per minute

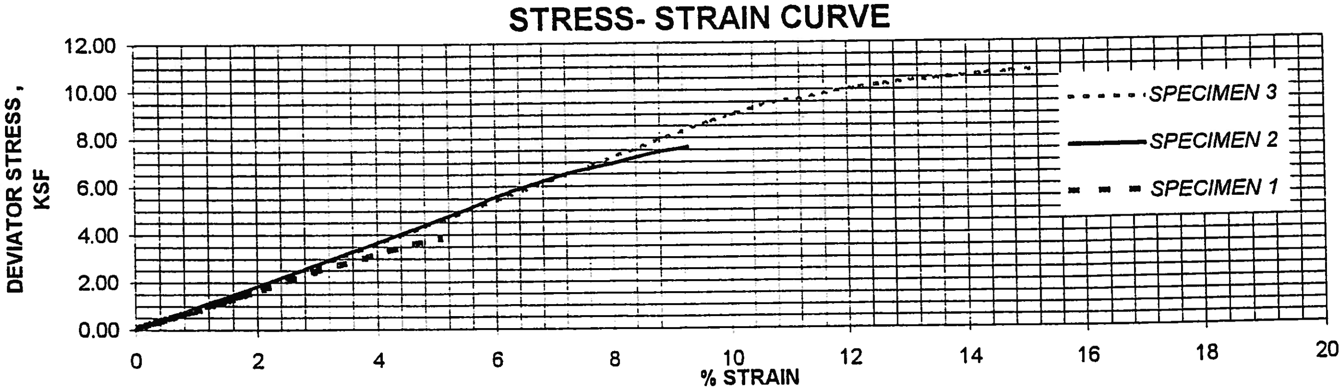
OTE : *THIS IS A MULTISTAGE TRIAXIAL*

SHEAR TRENGTH ARAMETERS	TOTAL		EFFECTIVE	
	COHESION , C (KSF) :	0.59	COHESION , C' (KSF) :	0.43
	ANGLE OF INTER. FRICTION, Φ(DEGREES) :	27.7	ANGLE OF INTER. FRICTION, Φ' (DEGREES) :	29.0

MOHR / p'-q DIAGRAM



STRESS- STRAIN CURVE



QORE™ PROPERTY SCIENCES

TRIAXIAL SHEAR TEST REPORT
(ASTM D 2850)

JOB NAME:	Arvin - Meritor Site						
JOB NO.:	22258	REPORT NO. :	191146	REVIEWED BY :		DATE	4/24/01
BORING / PIT NO. :	B-5	DEPTH / ELEV. :	6'-8'	SAMPLE NO . :	-	TYPE:	UD
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	Gray silty fine to medium sand .						
LIQUID LIMIT, % :	23	PLASTICITY INDEX , % :	4	FINES, % :	58	G_s :	2.61

SPECIMEN PROPERTIES

SPECIMEN NO.		INITIAL 1	2	3		AFTER CONSOLIDATION 1	2	3
DIAMETER , INCHES	D_o	2.86	-	-	D_c	2.85	-	-
HEIGHT , INCHES	H_o	5.86	-	-	H_c	5.85	-	-
WATER CONTENT, %	W_o	10.8	-	-	W_c	20.6	-	-
DRY DENSITY, PCF	γ_{dryo}	105.1	-	-	γ_{dryc}	105.9	-	-
SATURATION ,%	S_o	51.2	-	-	S_c	100	-	-
VOID RATIO	e_o	0.549	-	-	e_c	0.537	-	-

TEST TYPE : UU

TEST PARAMETERS

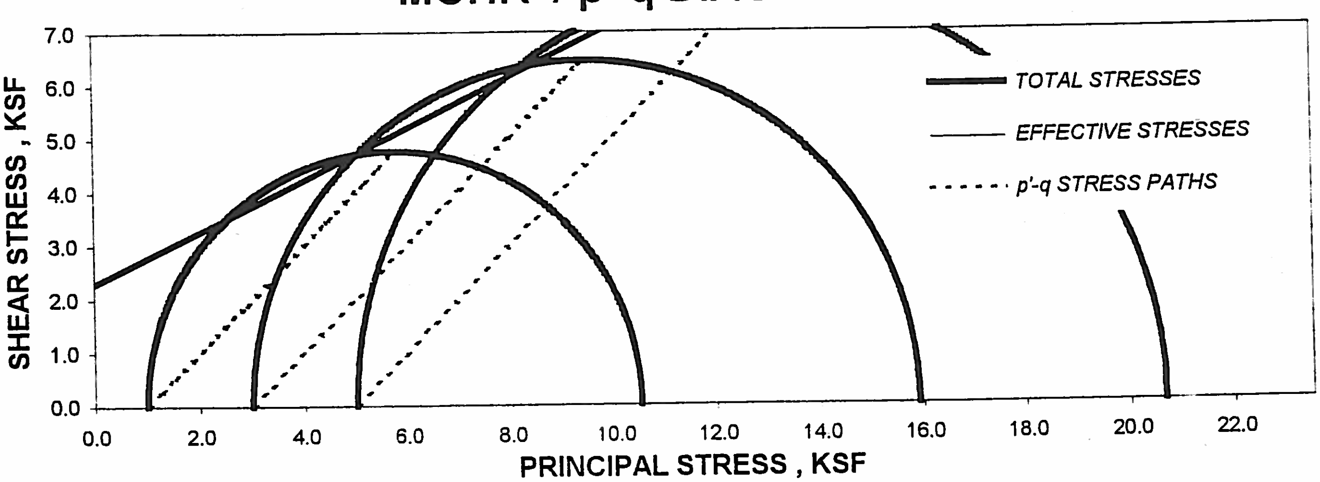
SPECIMEN NO.		1	2	3
BACK PRESSURE, KSF	U_o	0.0	0.0	0.0
CONFINING PRESSURE , KSF	σ_3	1.0	3.0	5.0
MAX. DEVIATOR STRESS ,KSF	σ_1-σ_3	-	-	15.7
ULT. DEVIATOR STRESS , KSF	σ_1-σ_3	-	-	15.0

CONTROLLED
Strain @ 0.5 % per minute

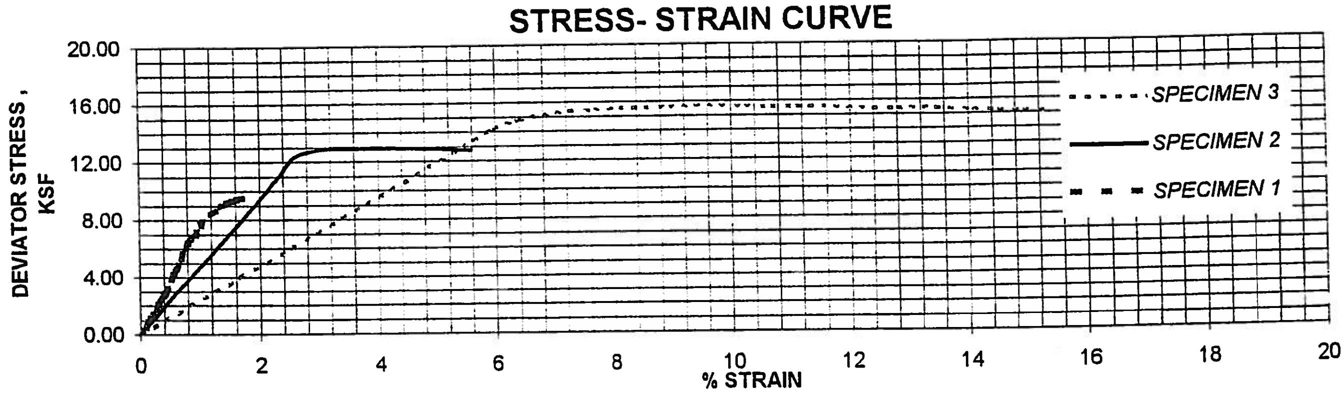
NOTE : *THIS IS A MULTISTAGE TRIAXIAL*

SHEAR STRENGTH PARAMETERS	TOTAL		EFFECTIVE	
	COHESION , C (KSF) :	2.29	COHESION , C' (KSF) :	-
	ANGLE OF INTER. FRICTION, Φ(DEGREES) :	25.7	ANGLE OF INTER. FRICTION, Φ' (DEGREES) :	-

MOHR / p'-q DIAGRAM



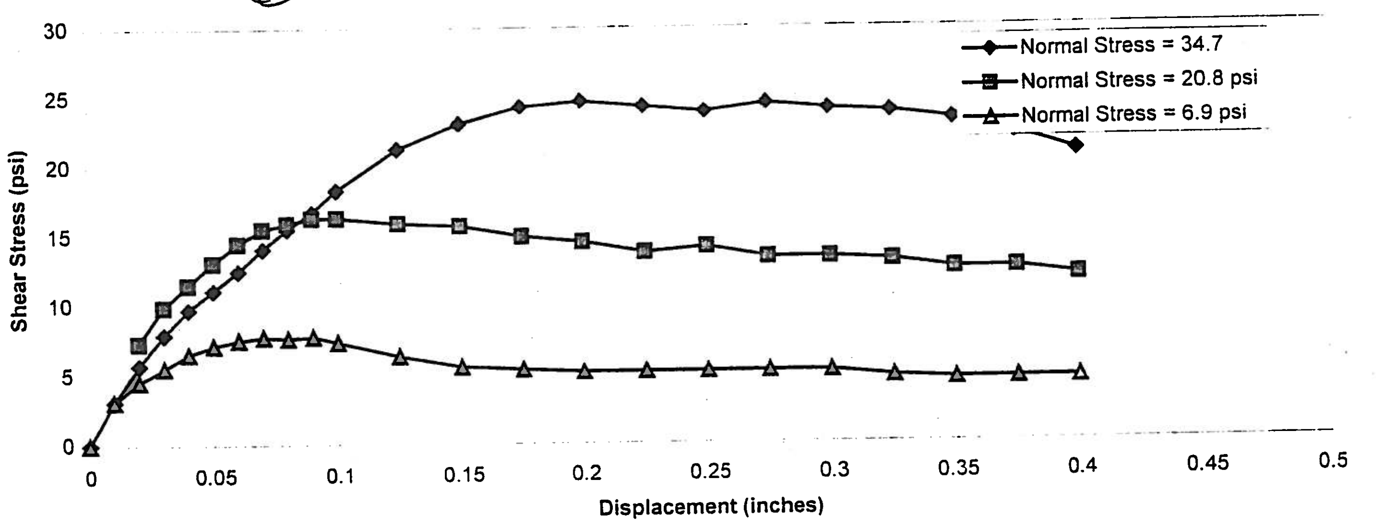
STRESS- STRAIN CURVE



DIRECT SHEAR TEST REPORT
(ASTM D 3080)

QORE

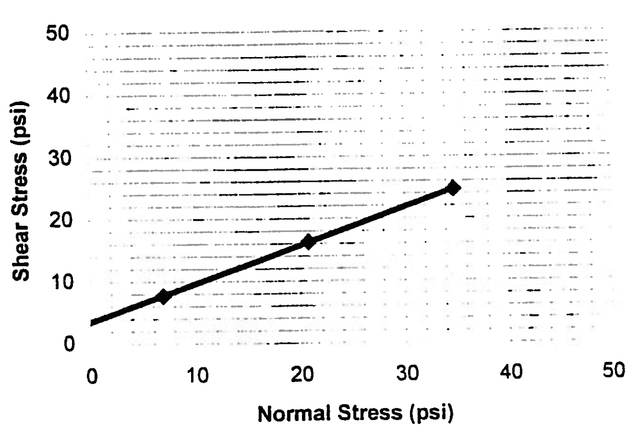
Job Name:	Arvin Meritor Site	Job Number:	22258
Location:	B - 2 @ 43.5'-45.5'	Report Number:	191146
Interface Tested:	Internal Shear Strength		
Soil Description:	Greyish silty fine to medium sand .		
Test Conditions:	Inundated		
Shear Rate:	0.010 Inches per minute		
Reviewed By:			



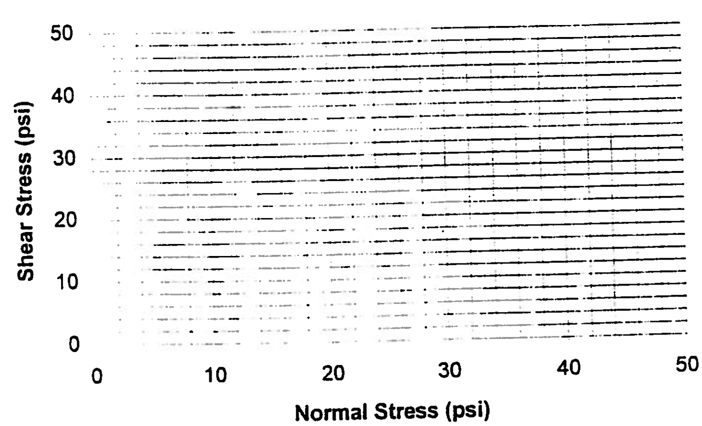
SPECIMEN NO.	MOISTURE CONTNET %	DRY UNIT WEIGHT PCF	POROSITY	% FINES
1	28.6	93.7	0.434	
2	33.1	91.8	0.445	
3	33.5	89.8	0.457	24

Normal Stress (psi)	Shear Stress Peak (psi)	Shear Stress Residual (psi)	SOIL Final Moisture Content (%)	Peak ϕ (degrees)	Peak c_c (psi)	Residual ϕ (degrees)	Residual c_c (psi)
6.9	7.70	-	-	31.3	3.5	-	-
20.8	16.26	-	-				
34.7	24.62	-	-				

Peak Shear Stress



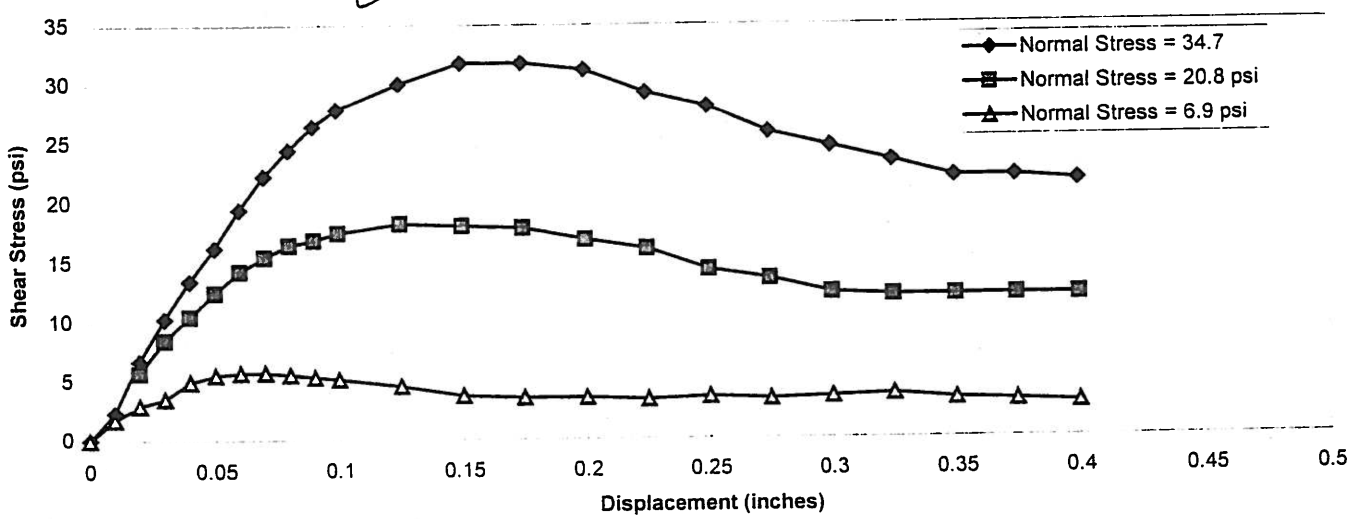
Residual Shear Stress



DIRECT SHEAR TEST REPORT
(ASTM D 3080)

QORE

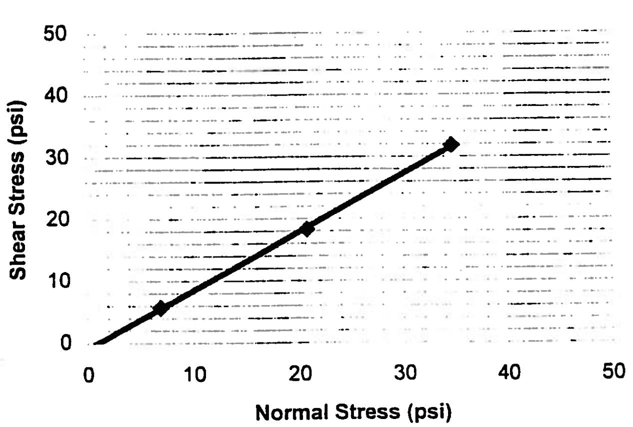
Job Name:	Arvin Meritor Site	**Job Number:**	22258
Location:	B - 3 @ 46.6'-47.6'	**Report Number:**	191146
Interface Tested:	Internal Shear Strength		
Soil Description:	Tan fine to medium sand .		
Test Conditions:	Inundated		
Shear Rate:	0.010 Inches per minute		
Reviewed By:			



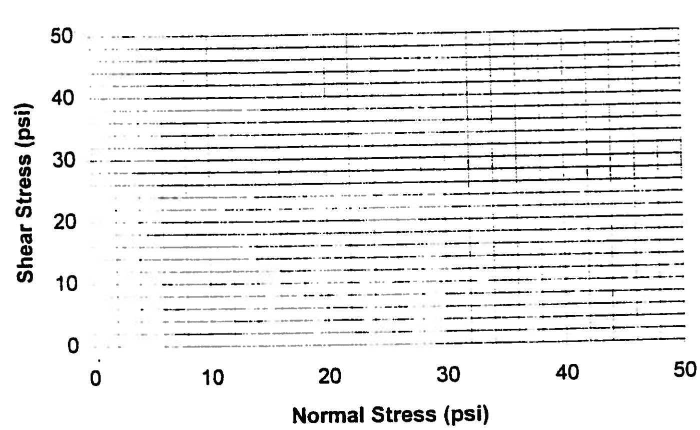
SPECIMEN NO.	MOISTURE CONTNET %	DRY UNIT WEIGHT PCF	POROSITY	% FINES
1	29.9	95.2	0.426	
2	25.9	102.1	0.385	
3	27.6	99.1	0.403	2

Normal Stress (psi)	Shear Stress Peak (psi)	Shear Stress Residual (psi)	SOIL Final Moisture Content (%)	Peak ϕ (degrees)	Peak c_c (psi)	Residual ϕ (degrees)	Residual c_c (psi)
6.9	5.71	-	-	**43.2**	**-0.9**	-	-
20.8	18.25	-	-				
34.7	31.78	-	-				

Peak Shear Stress



Residual Shear Stress

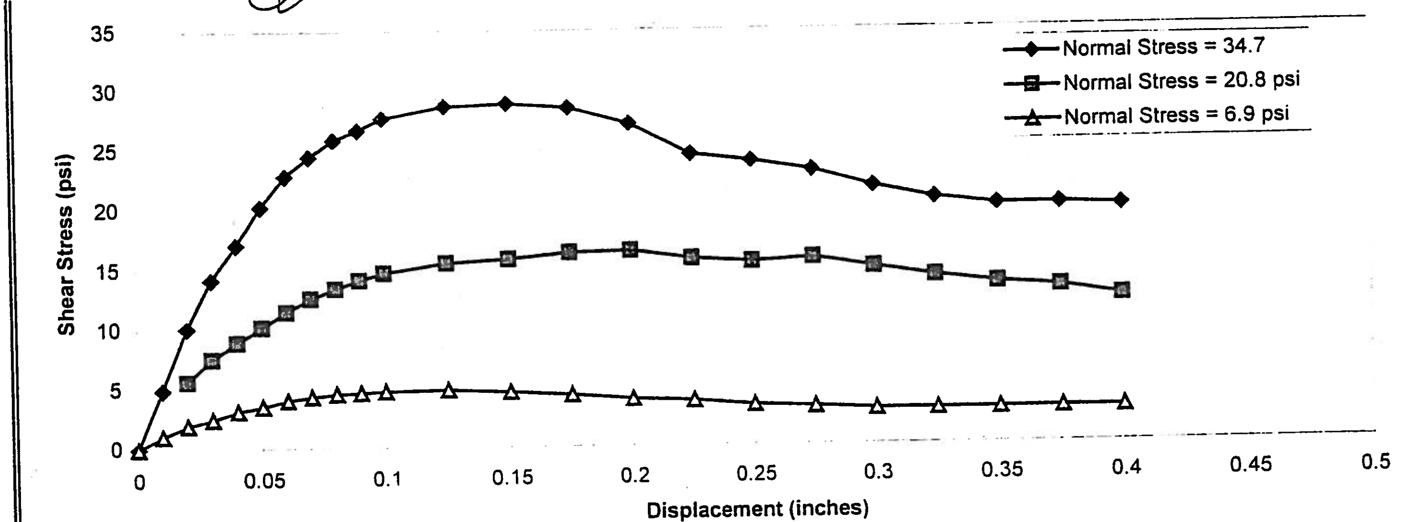


QORE

DIRECT SHEAR TEST REPORT
(ASTM D 3080)

AAP

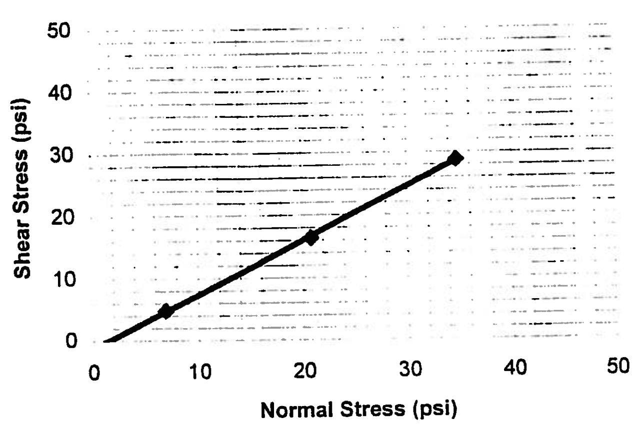
Job Name:	Arvin Meritor Site	**Job Number:**	22258
Location:	B - 5 @ 47'-49.2'	**Report Number:**	191146
Interface Tested:	Internal Shear Strength		
Soil Description:	Tan fine to medium sand .		
Test Conditions:	Inundated		
Shear Rate:	0.010 inches per minute		
Reviewed By:			



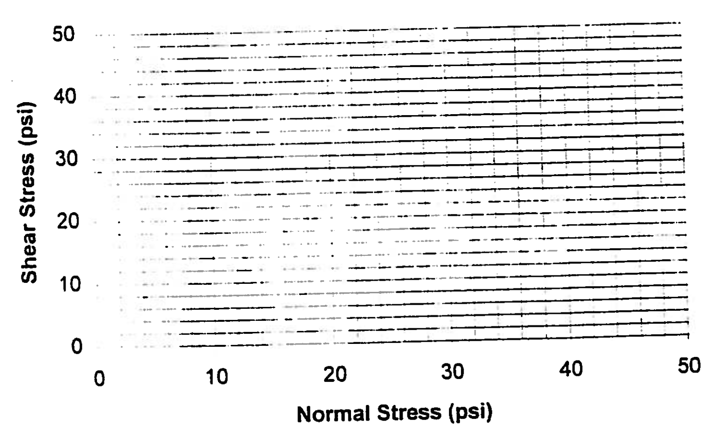
SPECIMEN NO.	MOISTURE CONTNET %	DRY UNIT WEIGHT PCF	POROSITY	% FINES
1	26.2	93.8	0.434	
2	30.1	92.2	0.443	
3	28.3	93.6	0.435	2

Normal Stress (psi)	Shear Stress		SOIL	Peak		Residual	
	Peak (psi)	Residual (psi)	Final Moisture Content (%)	ϕ (degrees)	c_c (psi)	ϕ (degrees)	c_c (psi)
6.9	4.82	-	-	**40.8**	**-1.3**	-	-
20.8	16.36	-	-				
34.7	28.79	-	-				

Peak Shear Stress



Residual Shear Stress

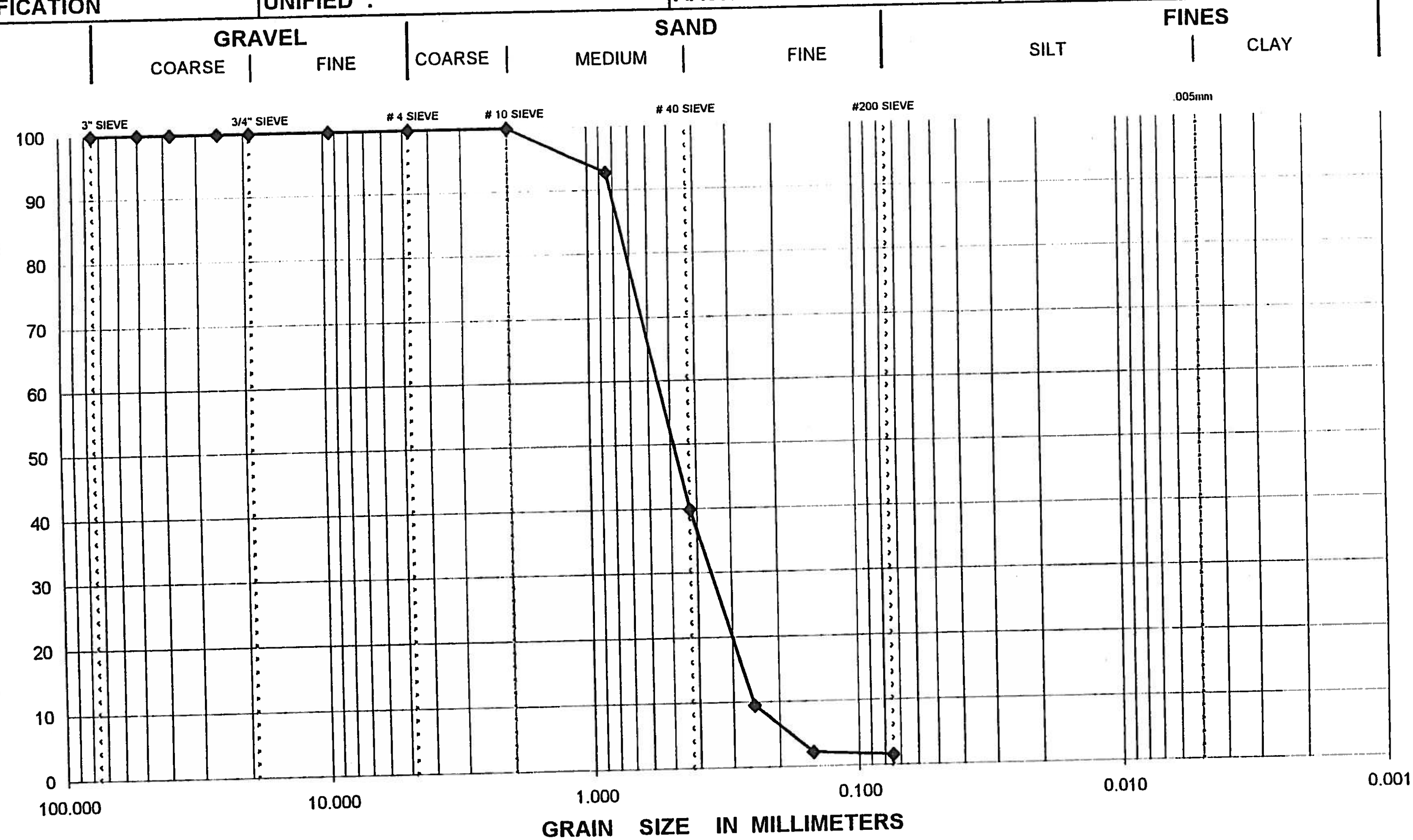


QORE PROPERTY SCIENCES

GRAIN SIZE DISTRIBUTION TEST REPORT
(ASTM D422)

AASHTO R18

JOB NAME :	Arvin - Meritor Site					REVIEWED BY :	
JOB NO. :	22258	REPORT NO. :	191146	DATE :	4/25/01	SAMPLE TYPE :	UD
BORING / PIT NO. :	B-3	DEPTH / ELEV. :	46'-47'	SAMPLE NO. :	-		
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	Tan fine to medium sand .					SP. GRAVITY, Gs :	-
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	-	FINES , % :	2
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF CURVATURE , C_C :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	-

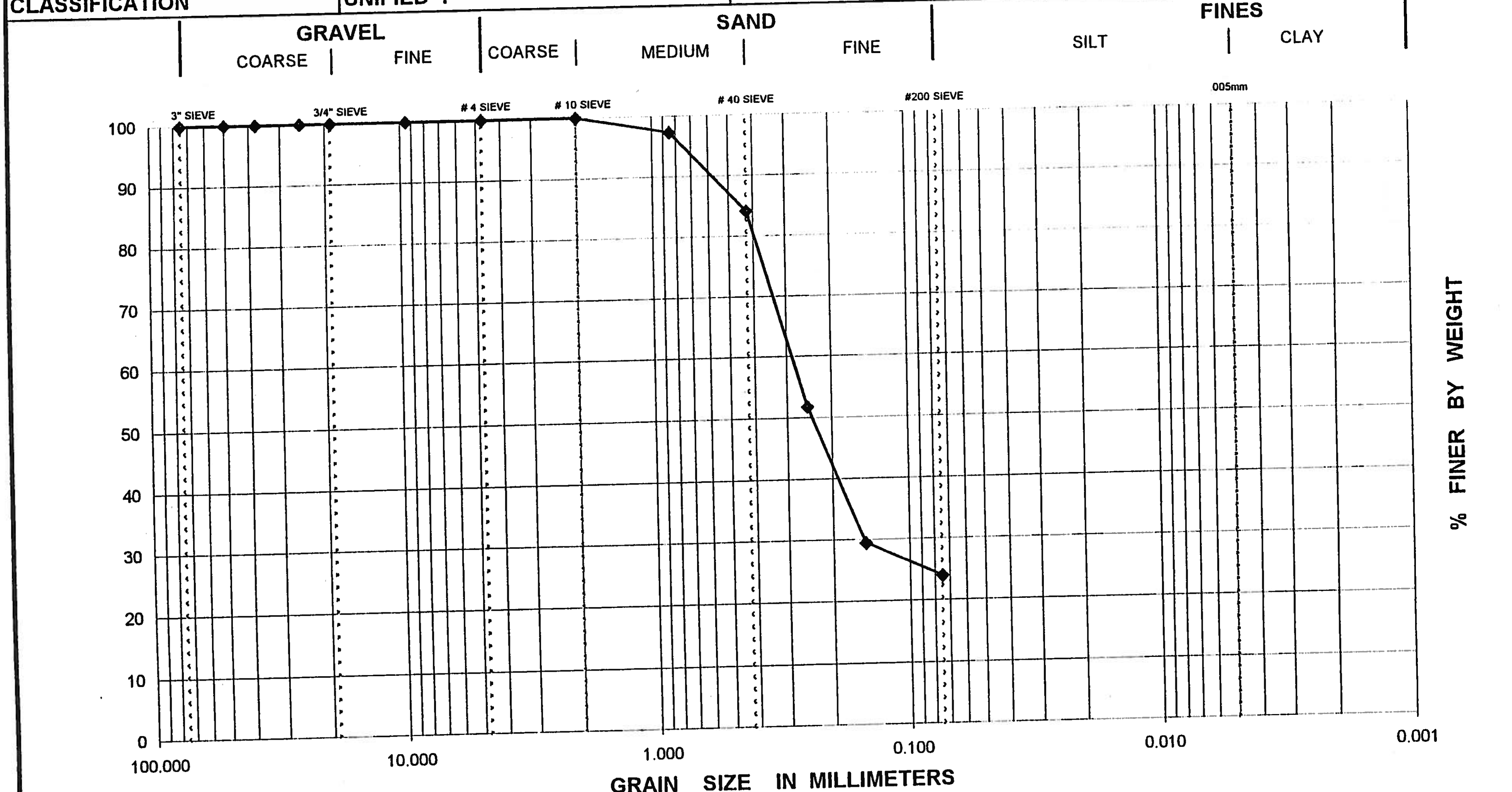


QORE PROPERTY SCIENCES

GRAIN SIZE DISTRIBUTION TEST REPORT
(ASTM D422)

AASHTO R18

JOB NAME :	Arvin - Meritor Site					REVIEWED BY :	
JOB NO. :	22258	REPORT NO. :	191146	DATE :	4/25/01	SAMPLE TYPE :	UD
BORING / PIT NO. :	B-2	DEPTH / ELEV. :	43.5'-45'	SAMPLE NO. :	-		
SAMPLE LOCATION :	-					SP. GRAVITY, Gs :	-
SOIL DESCRIPTION :	Greyish silty fine to medium sand .					FINES , % :	24
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	-	COEFF. OF CURVATURE , C_C :	-
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF UNIFORMITY , C_U :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-		

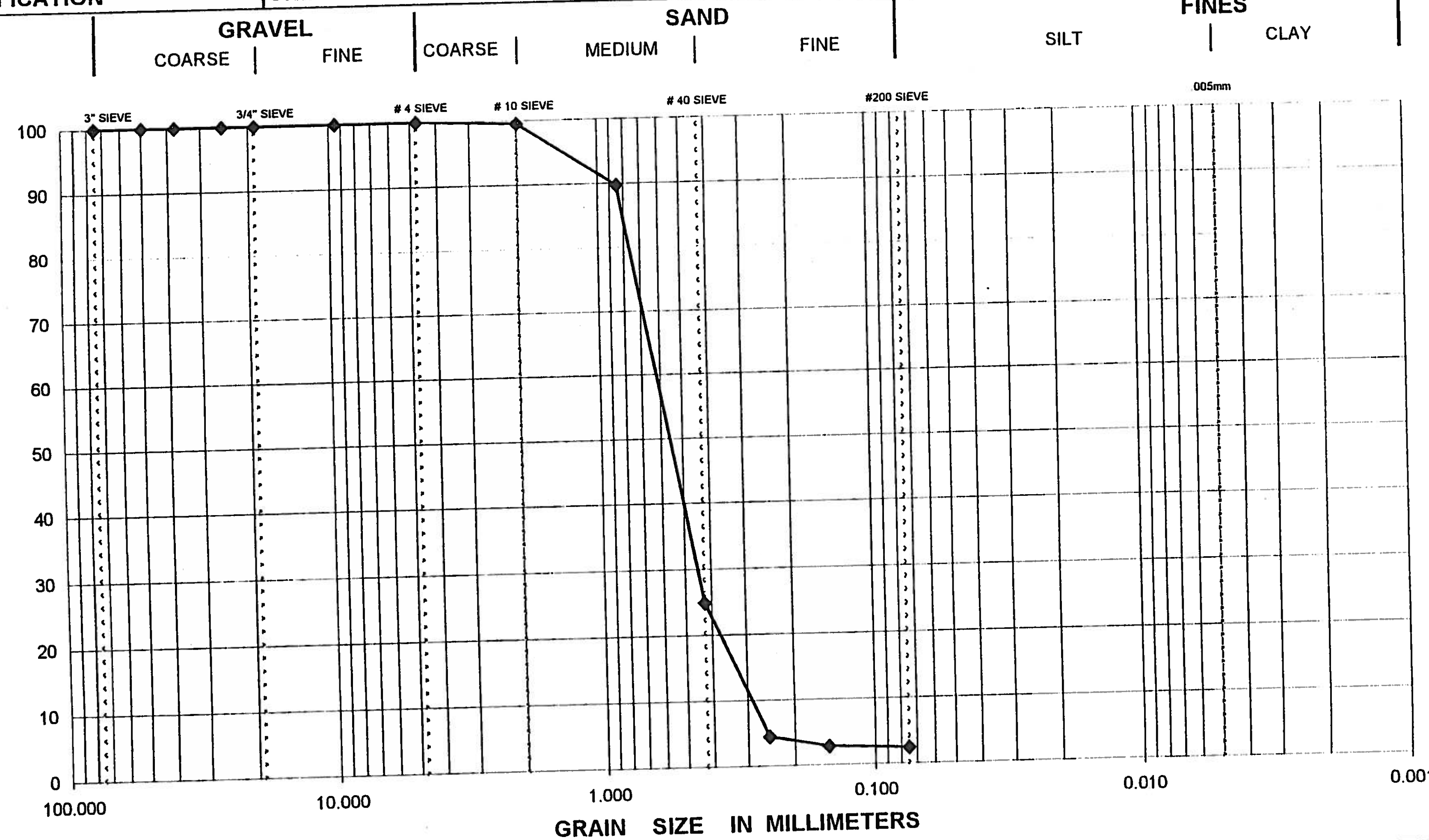


QORE™ PROPERTY SCIENCES

GRAIN SIZE DISTRIBUTION TEST REPORT
(ASTM D422)

AAP AASHTO R18

JOB NAME :	Arvin - Meritor Site					REVIEWED BY	
JOB NO. :	22258	REPORT NO. :	191146	DATE :	4/25/01	SAMPLE TYPE :	UD
BORING / PIT NO. :	B-5	DEPTH / ELEV. :	47'-49'	SAMPLE NO. :	-		
SAMPLE LOCATION :	-					SP. GRAVITY, Gs :	-
SOIL DESCRIPTION :	Tan gray fine to medium sand .					FINES , % :	2
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	-	COEFF. OF CURVATURE , C_C :	-
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF UNIFORMITY , C_U :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-		



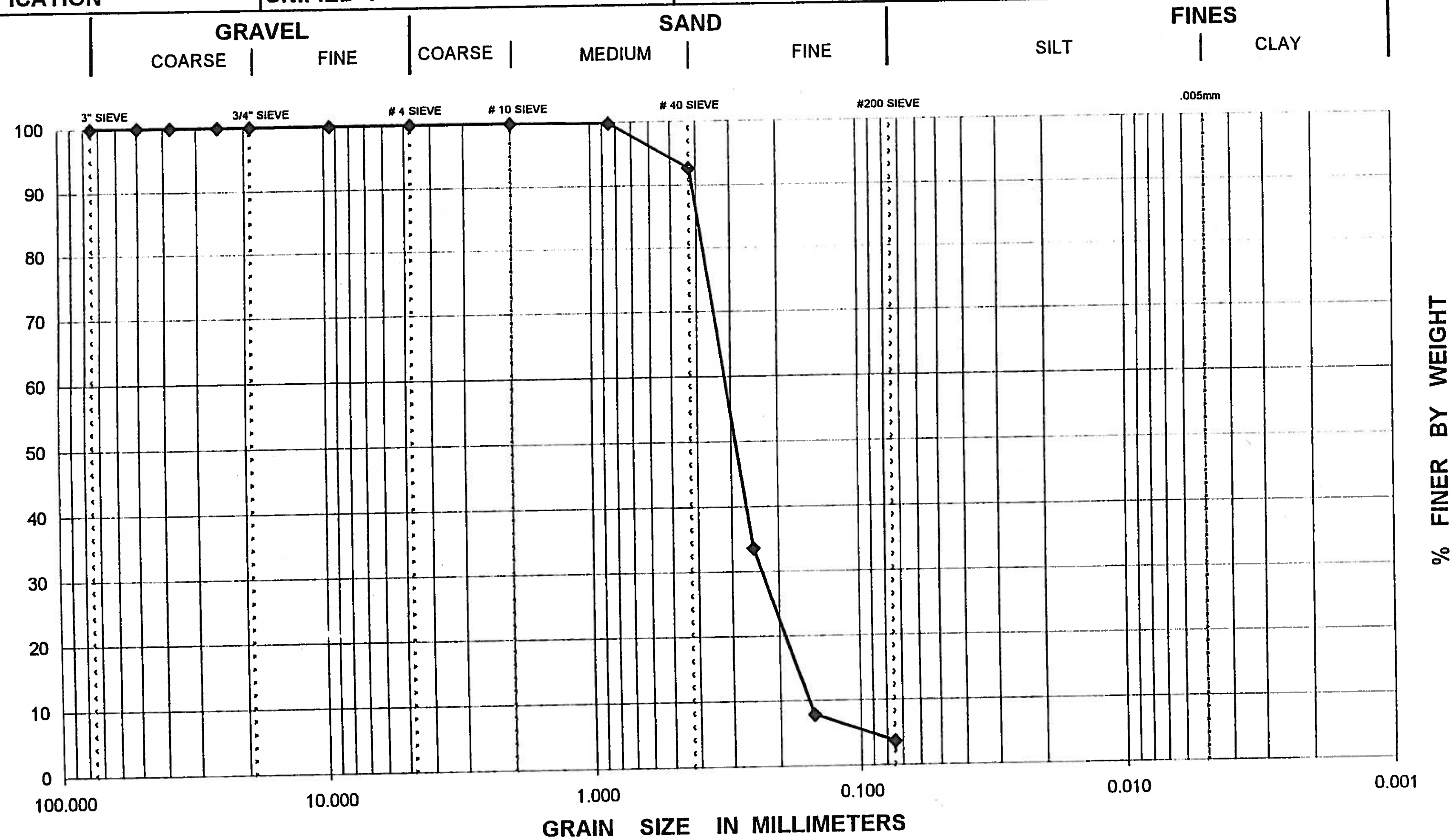
QORE™ PROPERTY SCIENCES

GRAIN SIZE DISTRIBUTION TEST REPORT

(ASTM D422)

AASHTO R18

JOB NAME :	Arvin - Meritor Site					REVIEWED BY :	
JOB NO. :	22258	REPORT NO. :	191146	DATE :	4/25/01		
BORING / PIT NO. :	B-1	DEPTH / ELEV. :	13.5'-15'	SAMPLE NO. :	-	SAMPLE TYPE :	SS
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	Tan gray fine to medium sand .					SP. GRAVITY, Gs :	-
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	26.9	FINES , % :	4
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF CURVATURE , C_C :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	-

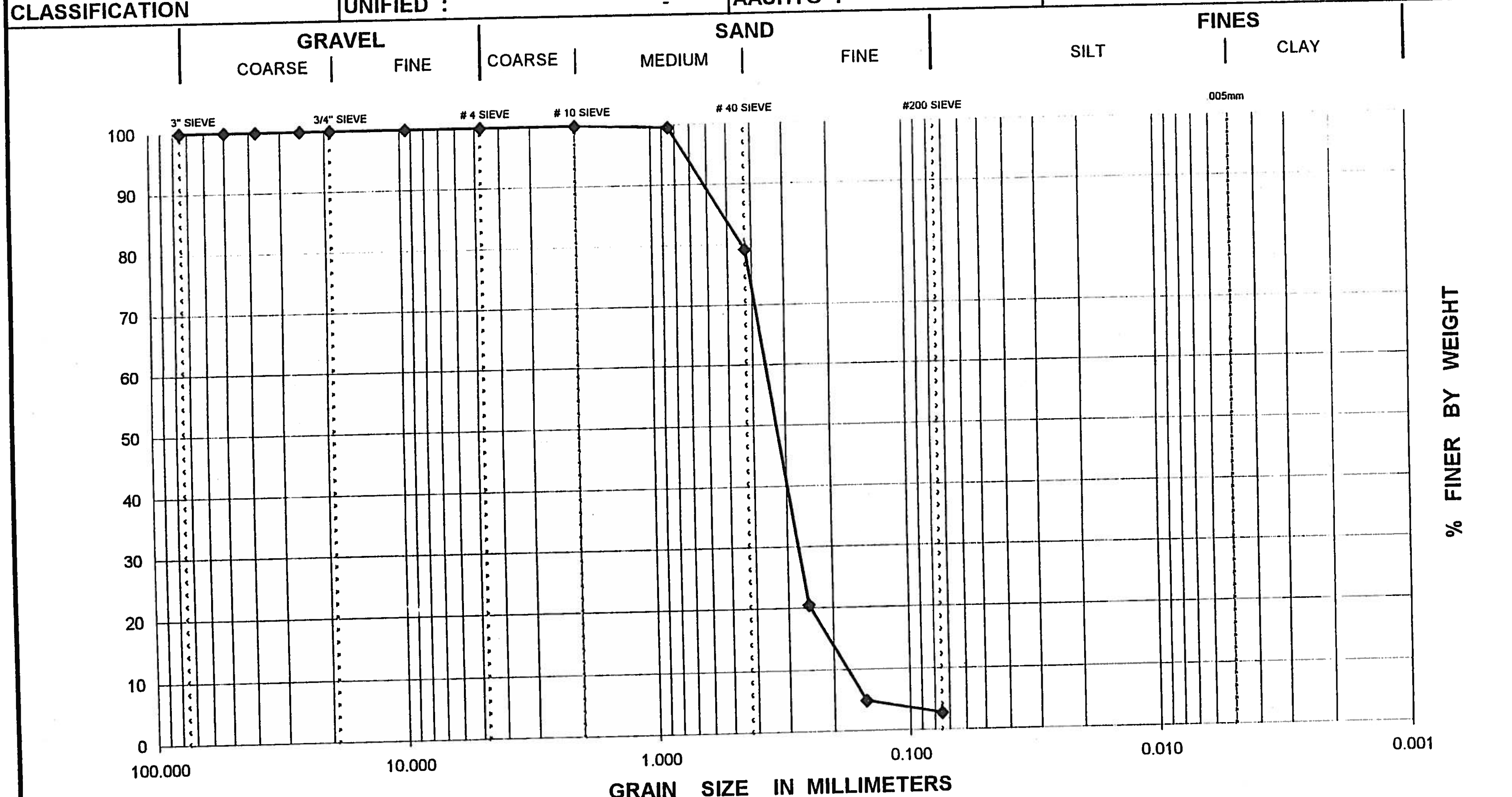


QORE™ PROPERTY SCIENCES

GRAIN SIZE DISTRIBUTION TEST REPORT
(ASTM D422)

AASHTO R18

JOB NAME :	Arvin - Meritor Site					REVIEWED BY :	
JOB NO. :	22258	REPORT NO. :	191146	DATE :	4/25/01	SAMPLE TYPE :	SS
BORING / PIT NO. :	B-1	DEPTH / ELEV. :	43.5'-45'	SAMPLE NO. :	-		
SAMPLE LOCATION :	-					SP. GRAVITY, Gs :	-
SOIL DESCRIPTION :	Tan gray fine to medium sand .					FINES , % :	3
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	27.7	COEFF. OF CURVATURE , C_c :	-
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF UNIFORMITY , C_u :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-		

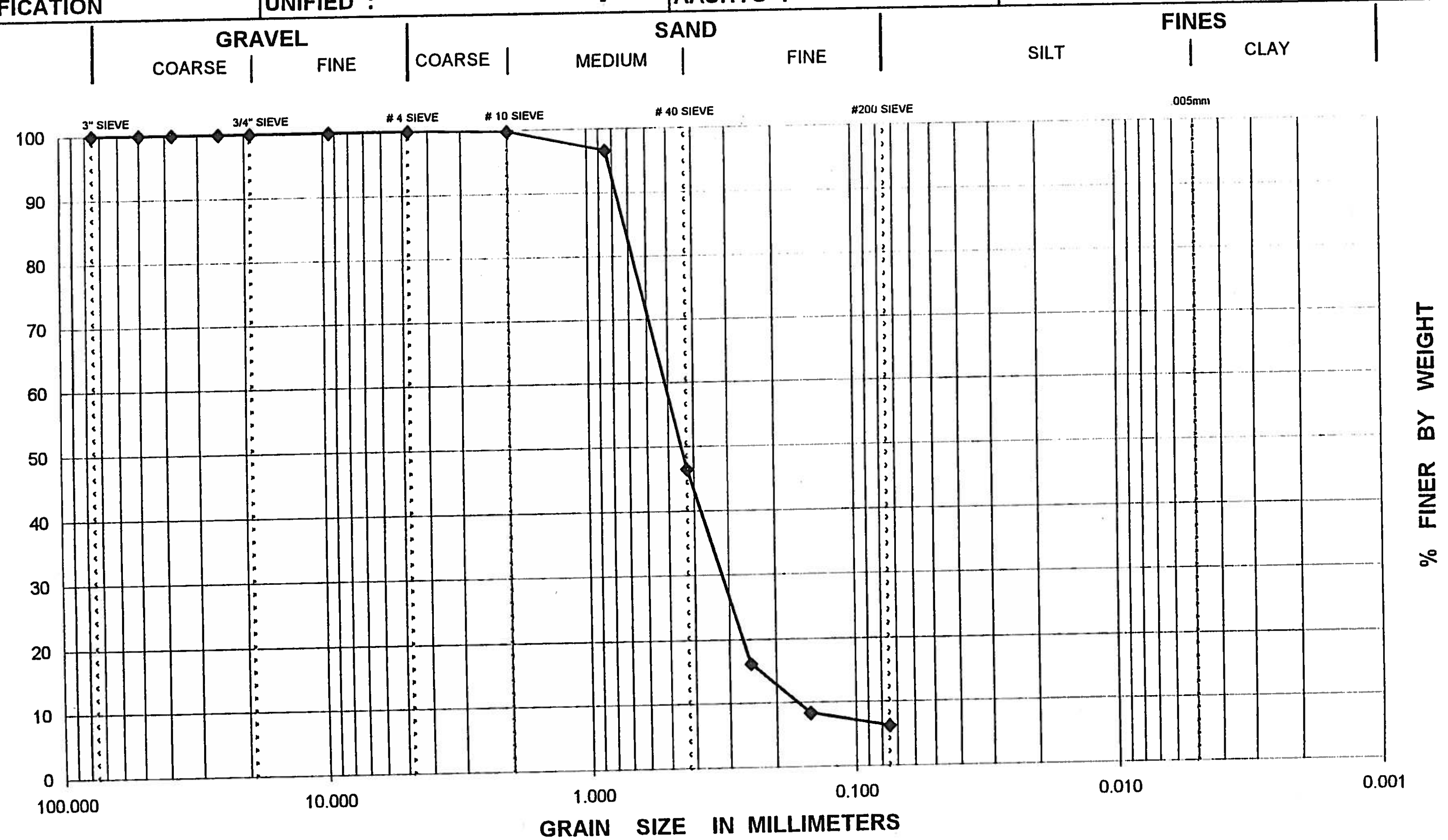


QORE PROPERTY SCIENCES

GRAIN SIZE DISTRIBUTION TEST REPORT
(ASTM D422)

AASHTO R18

JOB NAME :	Arvin - Meritor Site					REVIEWED BY	
JOB NO. :	22258	REPORT NO. :	191146	DATE :	4/25/01	SAMPLE TYPE :	SS
BORING / PIT NO. :	B-2	DEPTH / ELEV. :	18.5'-20'	SAMPLE NO. :	-		
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	Tan gray fine to medium sand .					SP. GRAVITY, Gs :	-
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	25.3	FINES , % :	6
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF CURVATURE , C_C :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	-

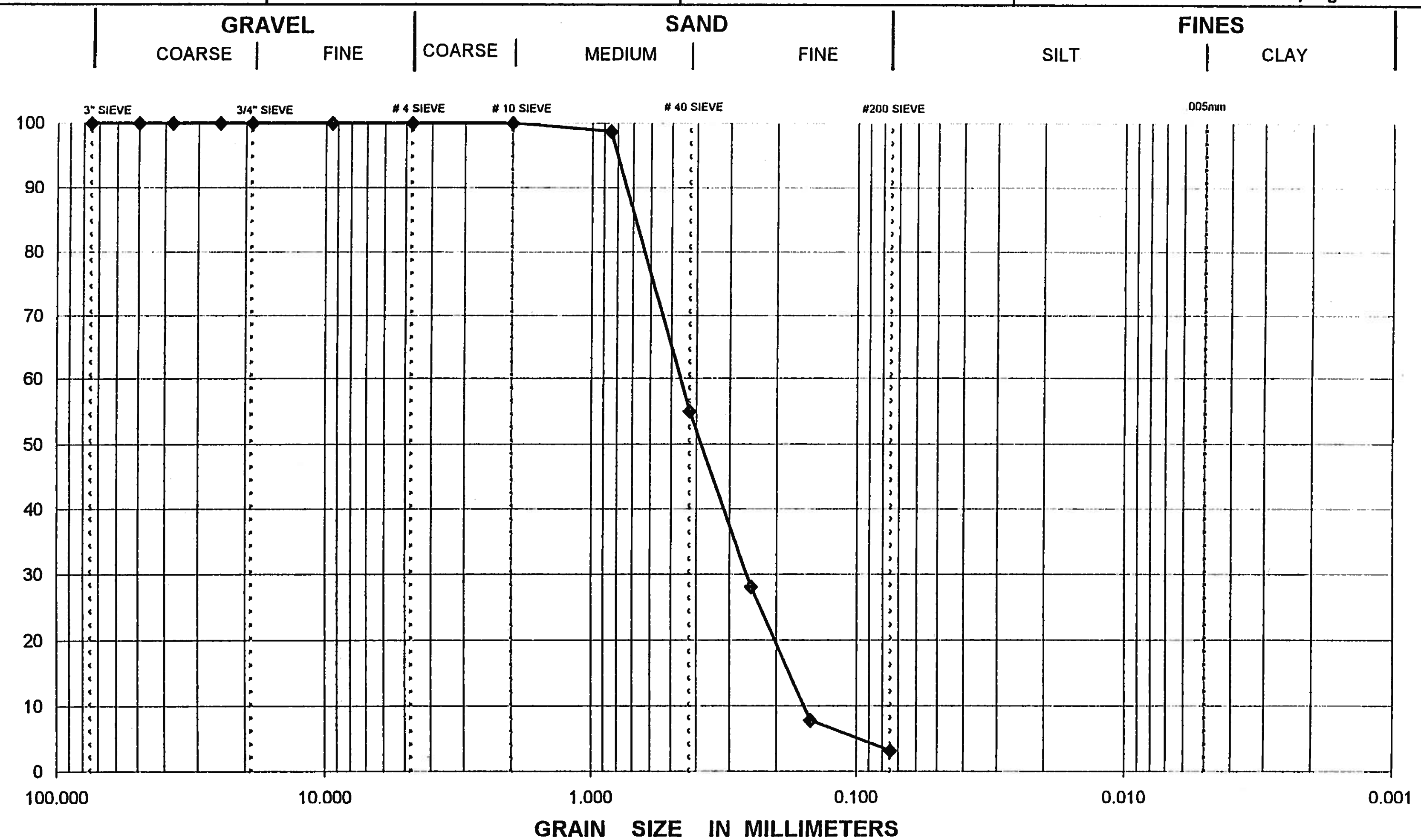


QORE PROPERTY SCIENCES

GRAIN SIZE DISTRIBUTION TEST REPORT
(ASTM D422)

AASHTO R18

JOB NAME :	Arvin - Meritor Site						
JOB NO. :	22258	REPORT NO. :	191146	DATE :	4/25/01	REVIEWED BY :	
BORING / PIT NO. :	B-4	DEPTH / ELEV. :	18.5'-20'	SAMPLE NO. :	-	SAMPLE TYPE :	SS
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	Tan gray fine to medium sand .					SP. GRAVITY, Gs :	-
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	21.7	FINES , % :	3
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF CURVATURE , C_C :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	-

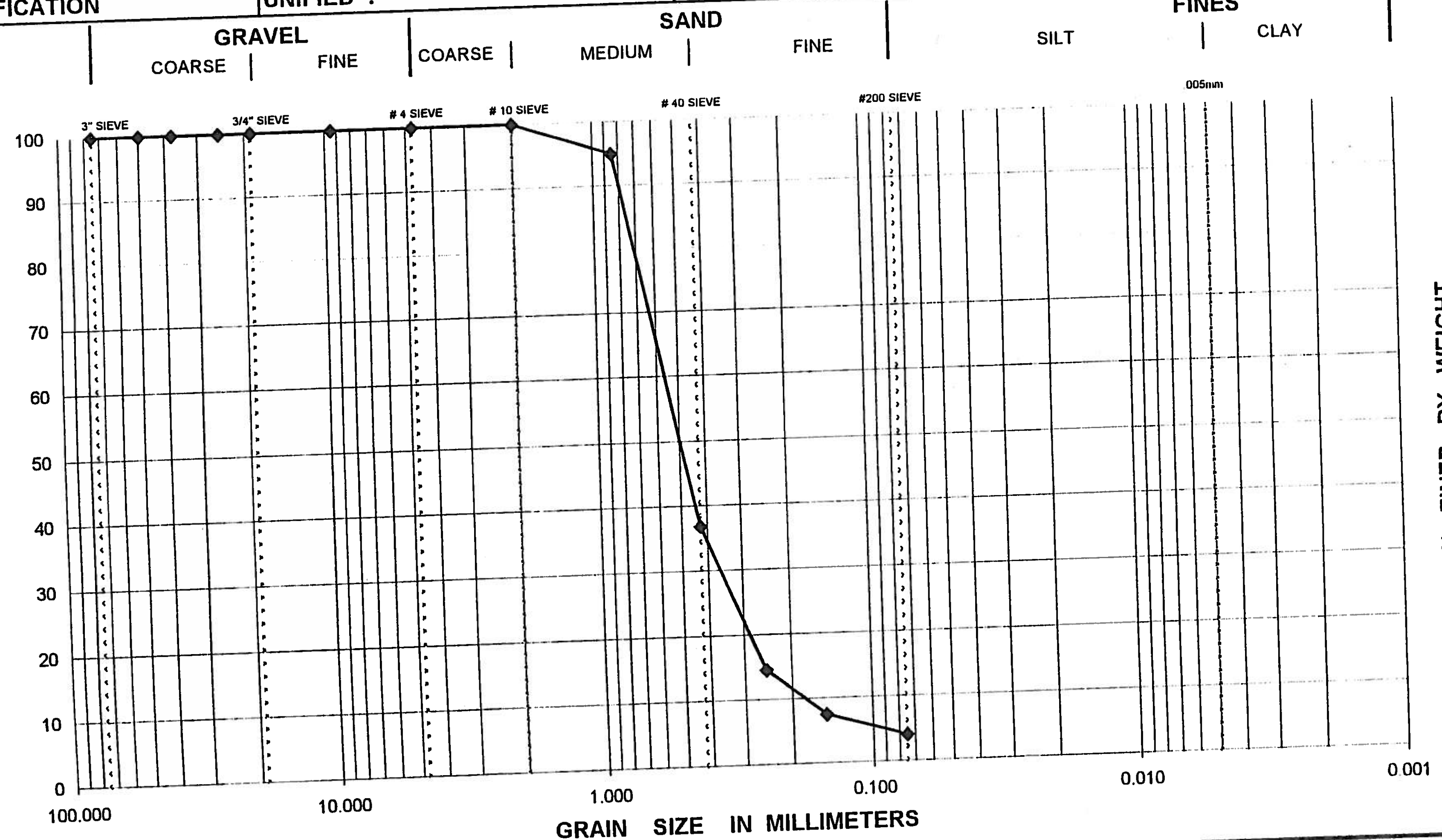


QORE PROPERTY SCIENCES

GRAIN SIZE DISTRIBUTION TEST REPORT
(ASTM D422)

AASHTO R18

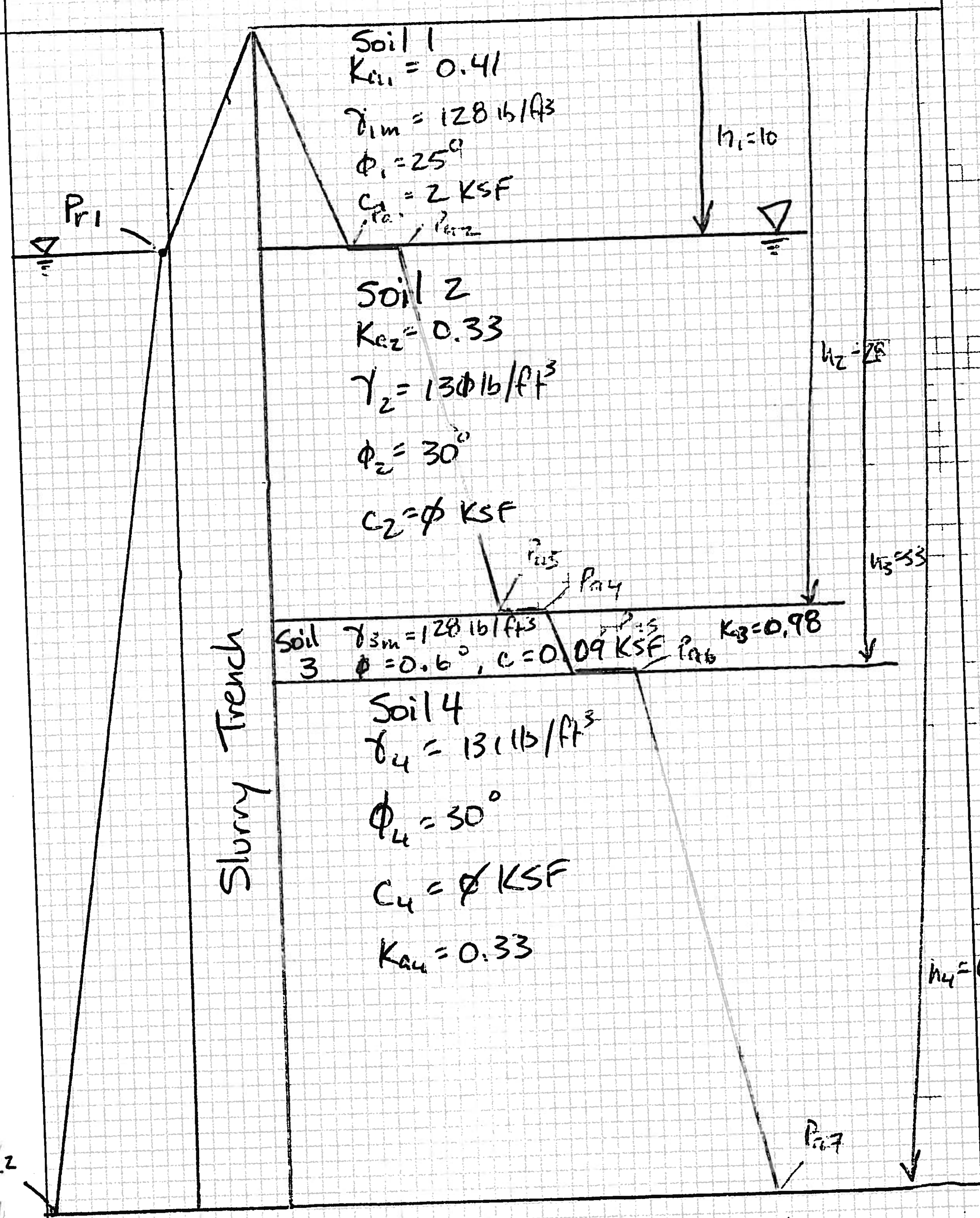
JOB NAME :	Arvin - Meritor Site					REVIEWED BY :	
JOB NO. :	22258	REPORT NO. :	191146	DATE :	4/25/01	SAMPLE TYPE :	SS
BORING / PIT NO. :	B-4	DEPTH / ELEV. :	38.5'-40'	SAMPLE NO. :	-		
SAMPLE LOCATION :	-					SP. GRAVITY, Gs :	-
SOIL DESCRIPTION :	Tan gray fine to medium sand .			MOISTURE , % :	20.3	FINES , % :	4
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	D60 , MM :	-	COEFF. OF CURVATURE , C_C :	-
D10 , MM :	-	D30 , MM :	-	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	-
CLASSIFICATION		UNIFIED :	-				



TRENCH STABILITY CALCULATIONS

BROWN AND CALDWELL

REFERENCES/NOTES



Assume slurry density of 64 gal/ft³

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
		19071.001	MJF	5/8/01	Case 1	1 / 4

PROJECT: Arvin – Meritor, Grenada MS

SUBJECT: Slurry Trench Stability Calculations

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

Case 1, 60 ft deep trench, no work platform.

$P_{a1} = \gamma_{1m} \times h_1 \times K_{a1}$

$= 128\ lb/ft^3 \times 10\ ft \times 0.41$

$= 524.8\ lbs/ft^2$

$P_{a2} = \gamma_{1m} \times h_1 \times K_{a2}$

$= (128\ lb/ft^3 \times 10\ ft \times 0.33)$

$= 423\ lbs/ft^2$

$P_{a3} = P_{a2} + (\gamma_2 - 62.4)(h_2 - h_1)(K_{a2})$

$= 423 + (131 - 62.4)(28 - 10)(0.33)$

$= 830\ lbs/ft^2$

$P_{a4} = [(\gamma_{1m} \times h_1) + (\gamma_2 - 62.4)(h_2 - h_1)] K_{a3}$

$= [(128)(10) + (131 - 62.4)(18)](0.98)$

$= 2{,}464\ lbs/ft^2$

$P_{a5} = P_{a4} + [(\gamma_3 - 62.4)(h_3 - h_2)] K_{a3}$

$= 2{,}464 + [(131 - 62.4)(33 - 28)] 0.98$

$= 2{,}801\ lbs/ft^2$

$P_{a6} = [(\gamma_{1m} \times h_1) + (\gamma_2 - 62.4)(h_2 - h_1) + (\gamma_3 - 62.4)(h_3 - h_2)] K_{a4}$

$= [(128 \times 10) + (131 - 62.4)(18) + (128 - 62.4)(5)] 0.33$

$= 938\ lbs/ft^2$

$P_{a7} = P_{a6} + [(\gamma_4 - 62.4)(h_4 - h_3)] K_{a4}$

$= 938\ lbs/ft^2 + [(131 - 62.4)(60 - 33)] 0.33$

BROWN AND CALDWELL

REFERENCES/NOTES

$P_{a7} = 1{,}550 \text{ lbs/ft}^2$

$$P_a = \left(h_1/2 \times P_{a1}\right) + \left(h_2 - h_1\right)\left(\frac{P_{a3} + P_{a2}}{2}\right) + \left(h_3 - h_2\right)\left(\frac{P_{a5} + P_{a4}}{2}\right)$$
$$+ \left(h_4 - h_3\right)\left(\frac{P_{a6} + P_{a7}}{2}\right)$$
$$= \left(525/2 \times 10\right) + \left(28 - 10\right)\left(\frac{423 + 830}{2}\right) + \left(33 - 28\right)\left(\frac{2{,}464 + 2{,}801}{2}\right)$$
$$+ \left(60 - 33\right)\left(\frac{938 + 1550}{2}\right)$$
$$= 2{,}625 + 11{,}277 + 13{,}162 + 33{,}588$$
$$= 60{,}652 \text{ lbs/ft}$$

Assume slurry height 1 ft below ground surface

$P_{r1} = \gamma_{slurry} \times h_1 = 64 \text{ lbs/ft}^3 \times (10\text{ft} - 1\text{ ft}) = 576 \text{ lbs/ft}^2$

$$P_{r2} = \left(\gamma_{slurry} - 62.4\right)\left(h_4 - h_1\right) + P_{r1}$$
$$= \left(64 - 62.4\right)\left(60 - 10\right) + 576$$
$$= 80 \text{ lbs/ft}^2 + 576$$
$$= 656 \text{ lbs/ft}^2$$

$$P_r = h_1/2 \times P_{r1} + \left(h_4 - h_1\right)\left(\frac{P_{r1} + P_{r2}}{2}\right)$$
$$= (10 - 1)/2 \times (576) + \left(60 - 10\right)\left(\frac{576 + 656}{2}\right)$$
$$= 2{,}592 + 30{,}800$$
$$= 33{,}392 \text{ lbs/ft}$$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
		19071.001	MF	5/8/01	Case 1	3/4

PROJECT: Arvin Meritor, Grenada, MS

SUBJECT: Slurry Trench Stability Calculations

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

It is assumed that the only soil with cohesion is soil #1.

Shear

$$\text{Shear} = \text{cohesion} \times (h_1) \times 1/\sin(45 + \phi/2)$$

$$= 2{,}000 \text{ lbs/ft}^2 \times 10 \text{ ft} \times 1.186$$

$$= 23{,}714 \text{ lbs/ft}$$

Factor of Safety

$$F.S. = \frac{(\text{Shear} + P_R)}{P_A} = \frac{(23{,}714 + 33{,}392)}{60{,}652} = \underline{0.94}$$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
		19071.001	MJF	5/8/01	Case 1	4 / 4

PROJECT: Arvin Meritor, Grenada, MS

SUBJECT: Slurry Trench Stability Calculations

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

Case 2, 50 ft deep trench, no work platform

$P_{a1} = \gamma_{1m} \times h_1 \times K_{a1}$

$= 128\ lb/ft^3 \times 10\ ft \times 0.41$

$= 525\ lb/ft^2$

$P_{a2} = \gamma_{1m} \times h_1 \times K_{a2}$

$= 128\ lb/ft^3 \times 10 ft \times 0.33$

$= 423\ lbs/ft^2$

$P_{a3} = P_{a2} + (\gamma_2 - 62.4)(h_2 - h_1)(K_{a2})$

$= 423 + (131 - 62.4)(28-10)(0.33)$

$= 830\ lbs/ft^2$

$P_{a4} = \left[(\gamma_{1m} \times h_1) + (\gamma_2 - 62.4)(h_2 - h_1)\right] K_{a3}$

$= \left[(128)(10) + (131-62.4)(28-10)\right](0.98)$

$= 2{,}464\ lbs/ft^2$

$P_{a5} = P_{a4} + \left[(\gamma_3 - 62.4)(h_3 - h_2)\right] K_{a3}$

$= 2{,}464 + \left[(131-62.4)(33-28)\right] 0.98$

$= 2{,}801\ lbs/ft^2$

$P_{a6} = \left[(\gamma_1 \times h_1) + (\gamma_2 - 62.4)(h_2 - h_1) + (\gamma_3 - 62.4)(h_3 - h_2)\right] K_{a4}$

$= \left[(128 \times 10) + (131-62.4)(18) + (128-62.4)(5)\right] 0.33$

$= 938\ lbs/ft^2$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
		19071.001	MJF	5/8/01	Case 2	1/3

PROJECT: Arvin Meritor, Grenada, MS

SUBJECT: Slurry Trench Stability Calculations

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

Case 2 continued

$P_{a7} = P_{a6} + [(\gamma_4 - 62.4)(h_4 - h_3)] K_{a4}$

$= 938 \text{ lbs/ft}^2 + [(131 - 62.4)(\underline{\underline{50}} - 33)] 0.33$

$= 1{,}323 \text{ lbs/ft}^2$

$P_a = (h_1/2 \times P_{a1}) + (h_2 - h_1)\left(\frac{P_{a3} + P_{a2}}{2}\right) + (h_3 - h_2)\left(\frac{P_{a5} + P_{a4}}{2}\right)$

$+ (h_4 - h_3)\left(\frac{P_{a6} + P_{a7}}{2}\right)$

$= (525/2 \times 10) + (28 - 10)\left(\frac{423 + 830}{2}\right) + (33 - 28)\left(\frac{2{,}464 + 2{,}801}{2}\right)$

$+ (\underline{\underline{50}} - 33)\left(\frac{938 + 1{,}323}{2}\right)$

$= 2{,}625 + 11{,}277 + 13{,}163 + 19{,}219$

$= \underline{46{,}284 \text{ lbs/ft}}$

Assume slurry height 1 ft below ground surface

$P_{r1} = \gamma_{slurry} * h_1 = 64 \text{ lbs/ft}^3 \times (10 \text{ ft} - 1 \text{ ft}) = 576 \text{ lbs/ft}^2$

$P_{r2} = P_{r1} + (\gamma_{slurry} - 62.4)(h_4 - h_1)$

$= 576 + (64 - 62.4)(50 - 10)$

$= 576 + 64$

$= 640 \text{ lbs/ft}^2$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
		19071.001	MJF	5/8/01	Case 2	2/3

PROJECT	SUBJECT
Arvin Meritor, Grenada, MS	Slurry Trench Stability Calculations

BROWN AND CALDWELL

REFERENCES/NOTES

Case 2 Continued

$$P_r = (h_1/2 \times P_{r1}) + (h_4 - h_1)\left(\frac{P_{r1} + P_{r2}}{2}\right)$$

$$= (9/2 \times 576) + (50 - 0)\left(\frac{576 + 640}{2}\right)$$

$$= 2{,}592 + 24{,}320$$

$$= 26{,}912 \text{ lbs/ft}$$

Shear

$$\text{Shear} = \text{cohesion} \times h_1 \times 1/\sin(45 + \phi/2)$$

$$= 2{,}000 \text{ lbs/ft}^2 \times 10 \text{ ft} \times 1/\sin(45 + 25/2)$$

$$= 2{,}000 \times 10 \times 1.186$$

$$= 23{,}720 \text{ lbs/ft}$$

Factor of Safety

$$F.S. = \frac{(\text{Shear} + P_r)}{P_A} = \frac{(23{,}720 + 26{,}912)}{46{,}284}$$

$$= 1.09$$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
		19071.001	MJF	5/8/01	Case 2	3/3

PROJECT: Arvin Meritor, Grenada, MS

SUBJECT: Slurry Trench Stability Calculations

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

Case 3, 60 ft Deep, 3 ft work platform

Assume work platform constructed of upper soil layer material

$P_{a1} = \gamma_1 \times (h_1 + \text{workplatform}) \times K_{a1}$

$= 128 \times (10 + 3) \times 0.41$

$= 683\ lb/ft^2$

$P_{a2} = \gamma_1 \times (h_1 + wp) \times K_{a2}$

$= 128 \times (10 + 3) \times 0.33$

$= 550\ lb/ft^2$

$P_{a3} = P_{a2} + (\gamma_2 - 62.4)(h_2 - h_1)(K_{a2})$

$= 550 + (131 - 62.4)(28 - 10)(0.33)$

$= 958\ lb/ft^2$

$P_{a4} = [(\gamma_1 \times (h_1 + wp)) + (\gamma_2 - 62.4)(h_2 - h_1)] K_{a3}$

$= [1664 + 1235](0.98)$

$= 2{,}841\ lb/ft^2$

$P_{a5} = P_{a4} + [(\gamma_3 - 62.4)(h_3 - h_2)] K_{a3}$

$= 2{,}841 + [128 - 62.4)(33 - 28)](0.98)$

$= 3{,}162\ lb/ft^2$

$P_{a6} = [(\gamma_1 \times h_1 + wp) + (\gamma_2 - 62.4)(h_2 - h_1) + (\gamma_3 - 62.4)(h_3 - h_2)] K_{a4}$

$= [(128)(10+3) + (131 - 62.4)(28 - 10) + (128 - 62.4)(5)] 0.33$

$= (3227)(0.33)$

$= 1{,}065\ lb/ft^2$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
		19071.001	MJF	5/9/01	Case 3	1 / 3

PROJECT: Arvin Meritor, Grenada, MS

SUBJECT: Slurry Trench Stability Calculations

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

Case 3 continued

$P_{a7} = P_{a6} + [(\gamma_4 - 62.4)(h_4 - h_3)] K_{a4}$

$= 1{,}065 + [(131 - 62.4)(60 - 33)] 0.33$

$= 1{,}677 \text{ lbs/ft}^2$

$P_a = \left(\frac{h_1 + wp}{2} \times P_{a1}\right) + (h_2 - h_1)\left(\frac{P_{a3} + P_{a2}}{2}\right) + (h_3 - h_2)\left(\frac{P_{a4} + P_{a5}}{2}\right)$

$+ (h_4 - h_3)\left(\frac{P_{a6} + P_{a7}}{2}\right)$

$= \left(\frac{(10+3)}{2} \times 683\right) + (28 - 10)\left(\frac{958 + 550}{2}\right) + (33 - 28)\left(\frac{2{,}84 + 3{,}162}{2}\right)$

$+ (60 - 33)\left(\frac{1{,}065 + 1323}{2}\right)$

$= 4{,}440 + 13{,}572 + 15{,}007 + 32{,}238$

$= 65{,}257 \text{ lbs/ft}$

Assume slurry height 1 ft below top of work platform

$P_{r1} = \gamma_{slurry} \times (h_1 + wp - 1\text{ ft}) = 64 \text{ lbs/ft}^3 \times (10 + 3 - 1)$
$= 768 \text{ lbs/ft}^2$

$P_{r2} = P_{r1} + (\gamma_{slurry} - 62.4)(h_4 - h_1)$

$= 768 \text{ lbs/ft}^2 + (64 - 62.4)(60 - 10)$

$= 848 \text{ lbs/ft}^2$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
		19071.001	MJF	5/9/01	Case 3	2/3

PROJECT	SUBJECT
Arvin Meritor, Grenada, MS	Slurry Trench Stability Calculations

BROWN AND CALDWELL

REFERENCES/NOTES

Case 3 continued

$$P_r = \frac{(h_1 + wp - 1)}{2}(P_{r1}) + (h_4 - h_1)\left(\frac{P_{r1} + P_{r2}}{2}\right)$$

$$= (6 \times 768) + (60-10)\left(\frac{768+848}{2}\right)$$

$$= 4{,}608 + 40{,}400$$

$$= 45{,}008 \text{ lb/ft}$$

Shear

$$\text{Shear} = \text{cohesion} \times h_1 \times 1/\sin(45 + \phi/2)$$

$$= 2{,}000 \text{ lbs/ft}^2 \times 10 \text{ ft} \times 1/\sin(45 + 25/2)$$

$$= 2{,}000 \times 10 \times 1.186$$

$$= 23{,}720 \text{ lbs/ft}$$

Factor of Safety

$$F.S. = \frac{(\text{Shear} + P_r)}{P_A} = \frac{23{,}720 + 45{,}008}{65{,}257}$$

$$= 1.05$$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
		19071.001	MJF	5/4/01	Case 3	3/3

PROJECT: Arvin Meritor, Grenada, MS

SUBJECT: Slurry Trench Stability Calculations

GEN-020-10/96

OUTFALL DITCH FLOW CALCULATIONS

Check: JPM 5/15/01

Project:	**Meritor Drainage Ditch**	**Date:** 5/15/01	25-yr, 30-min. Storm from Total Basin

Calculation of required depth of triangular surface ditch

References: Manual For Erosion and Sediment Control in Georgia, Fifth Edition, 2000.
Erosion and Sediment Pollution Control Program Manual, PA DER #466, 1991.

Manning's Equation:

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

$$A = bd + zd^2$$

$$R = \frac{bd + zd^2}{b + 2d(z^2 + 1)^{1/2}}$$

Ditch: Channel after Permeable Reactive Barrier.
Station: See Construction Plan Sheet (19071-03)

Predetermined Inputs: (see attached Tables)		
Enter Roughness Coefficient (Manning's n)	**0.040**	
Enter Base Dimension of Trapezoid in Feet (b)	**0.0** ft	
Enter Inside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**	
Enter Outside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**	
Is Ditch "bare earth" OR "lined"?	**lined**	**Bare initially, then rip-rap lined.(Use R-3, max velocity = 6.5 fps)**
Channel Construction	**Silty loam**	
Maximum permissible velocity for R-3 rip rap lined ditch	**6.50** fps	

Known Inputs:		
Enter Slope of Ditch (So)	**0.016** ft/ft	
Enter Drainage Area (in acres)	**27.14** acres	
Enter Runoff Coefficient	**0.95**	See Attached Table
Enter Intensity	**2.35** in	See Attached Figures
Enter Time of Concentration	**25** min	See Attached Nomograph
Peak Discharge	**60.59** cfs	Use 25 yr 30 min. event

Enter Trial Solution For Depth **2.500** ft

Trial Calculations:		Comment
Calculated Flow Volume =	**63.45** cfs	Acceptable
Calculated Flow Velocity =	**5.08** fps	Acceptable
Flow Area =	**12.50** sq. ft.	
Flow Depth =	**2.50** ft	
Top Flow Width =	**10.00** ft	
Wetted Perimeter =	**11.18** ft	

Critical Slope (Sc)=	**0.025** ft/ft	
Stable flow test (Unstable if 0.7Sc<So<1.3Sc)		Stable Flow
Lower Bound (0.7 x Sc)	**0.018**	
Slope of Ditch (So) =	**0.016**	
Upper Bound (1.3 x Sc)	**0.033**	

Free Board for Trial Calculation:	
If Unstable Flow, Freeboard = 0.075VD	**NA** ft
If Stable Flow, Freeboard = 0.5 for bare earth channels	**0.50** ft
Freeboard = larger of 0.5 or 0.25D for lined channels	**0.63** ft

Design Parameters based on Trial Calculation:		**Use**
Minimum Design Free Board =	**0.63** ft	
Minimum Design Channel Depth =	**3.13** ft	**3.5**
Minimum Design Channel Top Width =	**12.50** ft	**14.00**
Maximum Flow at Design Depth (includes freeboard depth) =	**115.03** cfs	**155.62**

Check: JPM 5/15/01

Project:	**Meritor Drainage Ditch**	**Date:**	5/15/01	25-yr, 30-min. Storm from Total Basin

Calculation of required depth of trapezoidal surface ditch

References: Manual For Erosion and Sediment Control in Georgia, Fifth Edition, 2000.
Erosion and Sediment Pollution Control Program Manual, PA DER #466, 1991.

Manning's Equation:

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

$$A = bd + zd^2$$

$$R = \frac{bd + zd^2}{b + 2d(z^2 + 1)^{1/2}}$$

Ditch: Channel after Permeable Reactive Barrier.
Station: See Construction Plan Sheet (19071-03)

Predetermined Inputs: (see attached Tables)			
Enter Roughness Coefficient (Manning's n)	**0.040**		
Enter Base Dimension of Trapezoid in Feet (b)	**4.2**	ft	
Enter Inside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**		
Enter Outside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**		
Is Ditch "bare earth" OR "lined"?	**lined**		**Bare initially, then rip-rap lined.(Use R-3, max velocity = 6.5 fps)**
Channel Construction	**Silty loam**		
Maximum permissible velocity for R-3 rip rap lined ditch	**6.50**	fps	
Known Inputs:			
Enter Slope of Ditch (So)	**0.016**	ft/ft	
Enter Drainage Area (in acres)	**27.14**	acres	
Enter Runoff Coefficient	**0.95**		See Attached Table
Enter Intensity	**2.35**	in	See Attached Figures
Enter Time of Concentration	**25**	min	See Attached Nomograph
Peak Discharge cfs per tributary acre	**60.59**	cfs	Use 25 yr 30 min. event
Enter Trial Solution For Depth	**1.700**	ft	
Trial Calculations:			Comment
Calculated Flow Volume =	**64.66**	cfs	Acceptable
Calculated Flow Velocity =	**5.00**	fps	Acceptable
Flow Area =	**12.92**	sq. ft.	
Flow Depth =	**1.70**	ft	
Top Flow Width =	**11.00**	ft	
Wetted Perimeter =	**11.80**	ft	
Critical Slope (Sc)=	**0.024**	ft/ft	
Stable flow test (Unstable if 0.7Sc<So<1.3Sc)			Stable Flow
Lower Bound (0.7 x Sc)	**0.017**		
Slope of Ditch (So) =	**0.016**		
Upper Bound (1.3 x Sc)	**0.032**		
Free Board for Trial Calculation:			
If Unstable Flow, Freeboard = 0.075VD	**NA**	ft	
If Stable Flow, Freeboard = 0.5 for bare earth channels	**0.50**	ft	
Freeboard = larger of 0.5 or 0.25D for lined channels	**0.50**	ft	
Design Parameters based on Trial Calculation:			<u>Use</u>
Minimum Design Free Board =	**0.50**	ft	
Minimum Design Channel Depth =	**2.20**	ft	**2.5**
Minimum Design Channel Top Width =	**13.00**	ft	**14.20**
Maximum Flow at Design Depth (includes freeboard depth) =	**108.77**	cfs	**141.72**

Check: gpm 5/18/01

Project: **Meritor Drainage Ditch** **Date:** 5/18/01 25-yr, 30-min. Storm from Eastern Basin

Calculation of required depth of triangular surface ditch
References: Manual For Erosion and Sediment Control in Georgia, Fifth Edition, 2000.
Erosion and Sediment Pollution Control Program Manual, PA DER #466, 1991.

Manning's Equation: $Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$

$A = bd + zd^2$

$R = \frac{bd + zd^2}{b + 2d(z^2 + 1)^{1/2}}$

Ditch: Channel after highway culvert.
Station: See Construction Plan Sheet (19071-03)

Predetermined Inputs: (see attached Tables)

Enter Roughness Coefficient (Manning's n)	**0.030**	
Enter Base Dimension of Trapezoid in Feet (b)	**0.0** ft	
Enter Inside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**	
Enter Outside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**	
Is Ditch "bare earth" OR "lined"?	**lined**	**Bare initially, then rip-rap lined.(Use R-3, max velocity = 6.5 fps)**
Channel Construction	**Silty loam**	
Maximum permissible velocity for R-3 rip rap lined ditch	**6.50** fps	

Known Inputs:

Enter Slope of Ditch (So)	**0.003** ft/ft	
Enter Drainage Area (in acres)	**27.14** acres	
Enter Runoff Coefficient	**0.95**	See Attached Table
Enter Intensity	**2.35** in	See Attached Figures
Enter Time of Concentration	**25** min	See Attached Nomograph
Peak Discharge	**60.59** cfs	Use 25 yr 30 min. event

Enter Trial Solution For Depth **2.970** ft

Trial Calculations:

		Comment
Calculated Flow Volume =	**60.82** cfs	Acceptable
Calculated Flow Velocity =	**3.45** fps	Acceptable
Flow Area =	**17.64** sq. ft.	
Flow Depth =	**2.97** ft	
Top Flow Width =	**11.88** ft	
Wetted Perimeter =	**13.28** ft	

Critical Slope (Sc)=	**0.013** ft/ft	
Stable flow test (Unstable if 0.7Sc<So<1.3Sc)		Stable Flow
Lower Bound (0.7 x Sc)	**0.009**	
Slope of Ditch (So) =	**0.003**	
Upper Bound (1.3 x Sc)	**0.017**	

Free Board for Trial Calculation:

If Unstable Flow, Freeboard = 0.075VD	**NA** ft
If Stable Flow, Freeboard = 0.5 for bare earth channels	**0.50** ft
Freeboard = larger of 0.5 or 0.25D for lined channels	**0.74** ft

Design Parameters based on Trial Calculation:

		Use
Minimum Design Free Board =	**0.74** ft	
Minimum Design Channel Depth =	**3.71** ft	**4**
Minimum Design Channel Top Width =	**14.85** ft	**16.00**
Maximum Flow at Design Depth (includes freeboard depth) =	**110.27** cfs	**134.54**

P:\PROJ\19071\IM Design\Drainage Calcs\E-25-30.xls

Check! JPM 5/18/01

Project: **Meritor Drainage Ditch** **Date:** 5/18/01 25-yr, 30-min. Storm from Eastern Basin

Calculation of required depth of trapezoidal surface ditch

References: Manual For Erosion and Sediment Control in Georgia, Fifth Edition, 2000.
Erosion and Sediment Pollution Control Program Manual, PA DER #466, 1991.

Manning's Equation: $Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$

$A = bd + zd^2$

$R = \frac{bd + zd^2}{b + 2d(z^2 + 1)^{1/2}}$

Ditch: Channel after highway culvert.
Station: See Construction Plan Sheet (19071-03)

Predetermined Inputs: (see attached Tables)		
Enter Roughness Coefficient (Manning's n)	**0.030**	
Enter Base Dimension of Trapezoid in Feet (b)	**6.2** ft	
Enter Inside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**	
Enter Outside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**	
Is Ditch "bare earth" OR "lined"?	**lined**	**Bare initially, then rip-rap lined.(Use R-3, max velocity = 6.5 fps)**
Channel Construction	**Silty loam**	
Maximum permissible velocity for R-3 rip rap lined ditch	**6.50** fps	
Known Inputs:		
Enter Slope of Ditch (So)	**0.003** ft/ft	
Enter Drainage Area (in acres)	**27.14** acres	
Enter Runoff Coefficient	**0.95**	See Attached Table
Enter Intensity	**2.35** in	See Attached Figures
Enter Time of Concentration	**25** min	See Attached Nomograph
Peak Discharge	**60.59** cfs	Use 25 yr 30 min. event
Enter Trial Solution For Depth	**1.900** ft	
Trial Calculations:		Comment
Calculated Flow Volume =	**64.33** cfs	Acceptable
Calculated Flow Velocity =	**3.39** fps	Acceptable
Flow Area =	**19.00** sq. ft.	
Flow Depth =	**1.90** ft	
Top Flow Width =	**13.80** ft	
Wetted Perimeter =	**14.70** ft	
Critical Slope (Sc)=	**0.013** ft/ft	
Stable flow test (Unstable if 0.7Sc<So<1.3Sc)		Stable Flow
Lower Bound (0.7 x Sc)	**0.009**	
Slope of Ditch (So) =	**0.003**	
Upper Bound (1.3 x Sc)	**0.017**	
Free Board for Trial Calculation:		
If Unstable Flow, Freeboard = 0.075VD	**NA** ft	
If Stable Flow, Freeboard = 0.5 for bare earth channels	**0.50** ft	
Freeboard = larger of 0.5 or 0.25D for lined channels	**0.50** ft	
Design Parameters based on Trial Calculation:		**Use**
Minimum Design Free Board =	**0.50** ft	
Minimum Design Channel Depth =	**2.40** ft	**2.5**
Minimum Design Channel Top Width =	**15.80** ft	**16.20**
Maximum Flow at Design Depth (includes freeboard depth) =	**101.28** cfs	**109.79**

From: Manual for Erosion and Sediment Control in Georgia, 2000.

APPENDIX A-3

PROCEDURAL GUIDE FOR COMPUTING RUN-OFF BY RATIONAL METHOD

The Rational Method is a method for determining run-off in terms of cubic feet per second at the drainage structure. It is based on the direct relationship between rainfall and run-off and may be expressed by the formula:

$$Q = CIA$$

Q = the run-off in cu. ft. per sec. from a given area.

C = a coefficient representing the ratio of run-off to rainfall (related to impervious area) i.e., 1.0 - 100% run-off.

I = the intensity of rainfall in inches per hour for a duration equal to the time of concentration and for a stated frequency.

A = the drainage area in acres.

		SOIL CLASSIFICATION			
SLOPE	LAND USE	SAND OR SANDY LOAM SOILS (Pervious) Min.	Max.	HIGH CLAY SOILS (Impervious) Min.	Max.
Flat (0% - 3%)	Woodlands	0.15	0.20	0.20	0.25
	Pasture	0.20	0.25	0.25	0.30
	Paved	0.95		0.95 E,SW	
	Residential	0.35	0.60	0.50	0.60 NW
	Commercial	0.60	0.95	0.60	0.95
Rolling (3% - 7%)	Woodlands	0.15	0.20	0.18	0.25
	Pasture	0.30	0.40	0.35	0.45
	Paved	0.95		0.95	
	Residential	0.50	0.60	0.50	0.60
	Commercial	0.60	0.95	0.60	0.95
Hilly (7% - 11%)	Woodlands	0.20	0.25	0.25	0.30
	Pasture	0.35	0.45	0.45	0.55
	Paved	0.95		0.95	
	Residential	0.50	0.60	0.50	0.60
	Commercial	0.60	0.95	0.60	0.95
Mountainous (11% +)	Woodlands			0.70	0.80
	Bare		0.80	0.80	0.95
Steep Grassed Slopes	Pasture	0.70		0.70	

Table A-3.1

1. Determine "C" by observation in the field of culture and soils and by use of Table A-3.1, p. A-3-1.

2. Determine "I" (intensity rate) from the time of Concentration Figure A-3.1, p. A-3-3 and Rainfall Figures A-3.3 through A-3.7, p. A-3-5 through A-3-9.

NOTE:

a. Height (ft.) is determined in the field or from contour maps. Height is the difference in elevation of the most remote point in the drainage area and the inlet flow line of the structure.

b. Maximum length of travel is determined in the field or from the contour maps. It is the greatest distance the water will travel from the most remote point of the drainage area to the inlet of the drainage structure.

c. Use height and length to determine the time of concentration by use of Figure A-3.1. Use a minimum of 10 minutes for rural and urban areas.

d. Now refer to rainfall figures - Atlanta, Macon, Augusta, Thomasville and Savannah (use figure nearest to project or combination of two figures) and by scaling the time of concentration, which is equal to the rainfall duration, along the bottom of the table and moving up to the selected return period, (10-25-50 yr.), move horizontally to the left and read the intensity "I".

3. Determine the time of concentration using the "Kinematic Wave Nomograph," Figure A-3.2, p. A-3-4. The kinematic wave table incorporates variables, the rainfall intensity and mannings "n." In using the nomograph, the designer has two unknowns starting the computations, the time of concentration and the rainfall density. The problem is attempting to determine a rainfall intensity which, in turn, actually determines the time of concentration. Thus, the problem is one of iteration. A value of "i" must be assumed, compute a time of concentration and then check back to see if the rainfall intensity that was assumed is consistent with the frequency curve of Figures A-3.3 through A-3.7. If one is the given length, slope, roughness coefficient, and intensity-duration-frequency curve the steps are as follows:

a. Assume rainfall intensity.
b. Use kinematic wave nomograph or equation to obtain first estimate of time concentration.
c. Using the time of concentration obtained from Step "b", enter Figures A-3.3 through A-3.7 for appropriate area and find rainfall intensity corresponding to the computed time of concentration. If this rainfall intensity corresponds with the assumed intensity, the problem is solved. If not, proceed to Step "d".
d. Assume a new rainfall intensity that is betwen that assumed in Step "a" and that determined in Step "c."
e. Repeat Steps "a" through "c" until there is good agreement between the assumed rainfall intensity and that obtained from Figures A-3.3 through A-3.7. Experience has shown that a solution can be found on the third iteration with little difficulty.

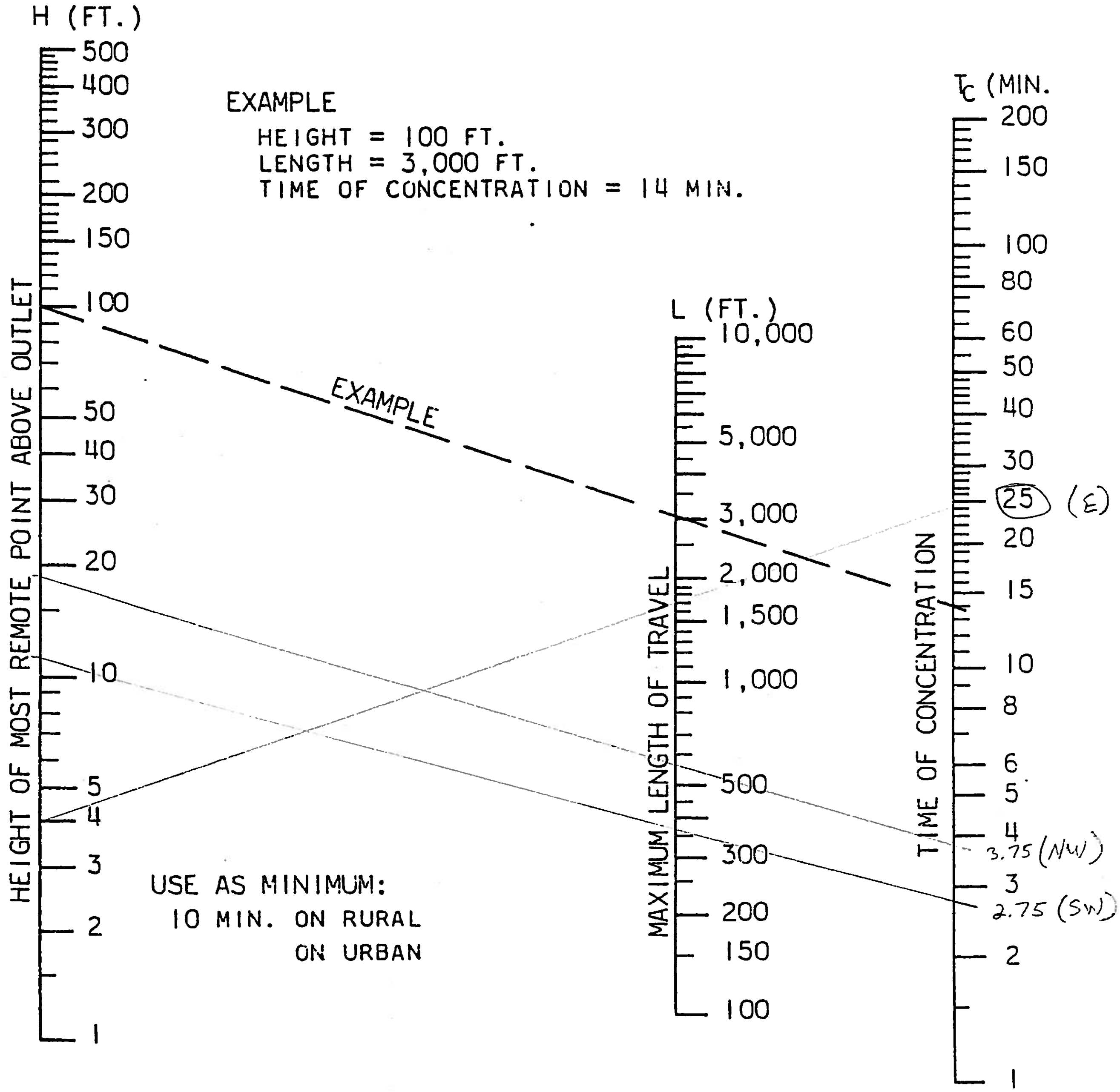
Generally, the time of concentration for overland flow is only a part of the overall design problem. Often one encounters swale flow, confined channel flow, and closed conduit flow-times that must be added as part of the overall time of concentration. When this situation is encountered, it is best to compute the confined flow-times as the first step in the overall determination of the time of concentration. This will give the designer a rough estimate of the time involved for the overland flow which will give a better first start on the rainfall intensity assumption. For example, if the flow time in a channel is 15 minutes and the overland flow time from this ridge line to the channels is 10 minutes, then the total time of concentration is 25 minutes. The channel flow can be determined by length divided by velocity.

4. Determine drainage Area "A" in the field or from contour maps.

5. Multiply the values of C x I x A to determine Q (cu. ft. per sec.).

6. Using "Q" as determined above, solve for size of structure required by use of Culvert Capacity Charts or nomographs.

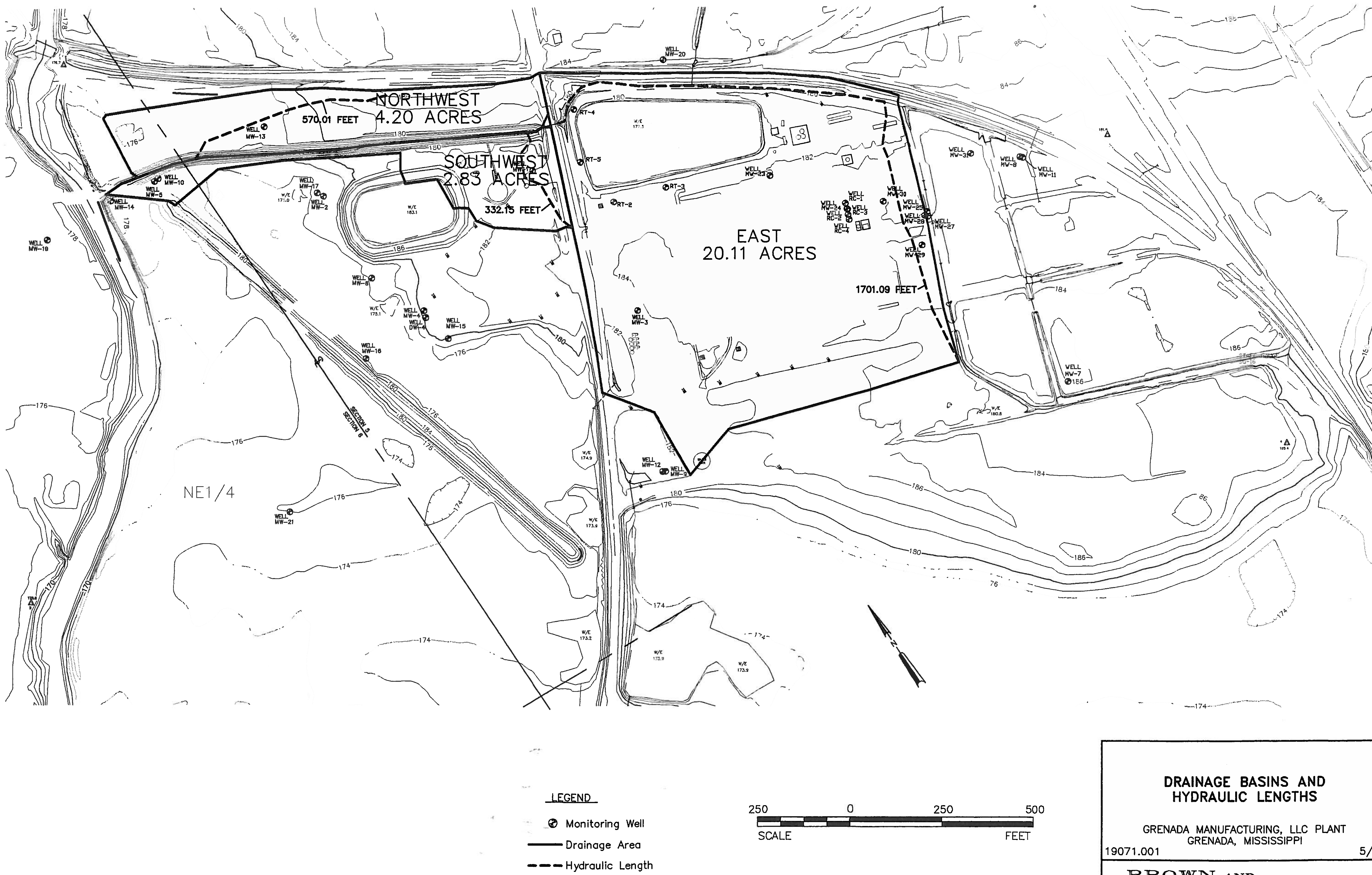
Table A-3.2, p. A-3-10 may be used for organizing computation.



TIME OF CONCENTRATION OF SMALL DRAINAGE BASINS

Based on study by P. Z. Kirpich,
Civil Engineering, Vol. 10, No. 6, June 1940, p.362

Figure A-3.1



SOURCE: MAP PREPARED BY ALMON ASSOCIATES, 1993. WELL LOCATIONS SHOWN ARE APPROXIMATE.

DRAWING NO.: AREAS.DWG DATE: 5/15/01 PLOT SCALE 1=250

DRAINAGE BASINS AND HYDRAULIC LENGTHS

GRENADA MANUFACTURING, LLC PLANT
GRENADA, MISSISSIPPI

19071.001 5/01

BROWN AND CALDWELL Nashville, Tennessee

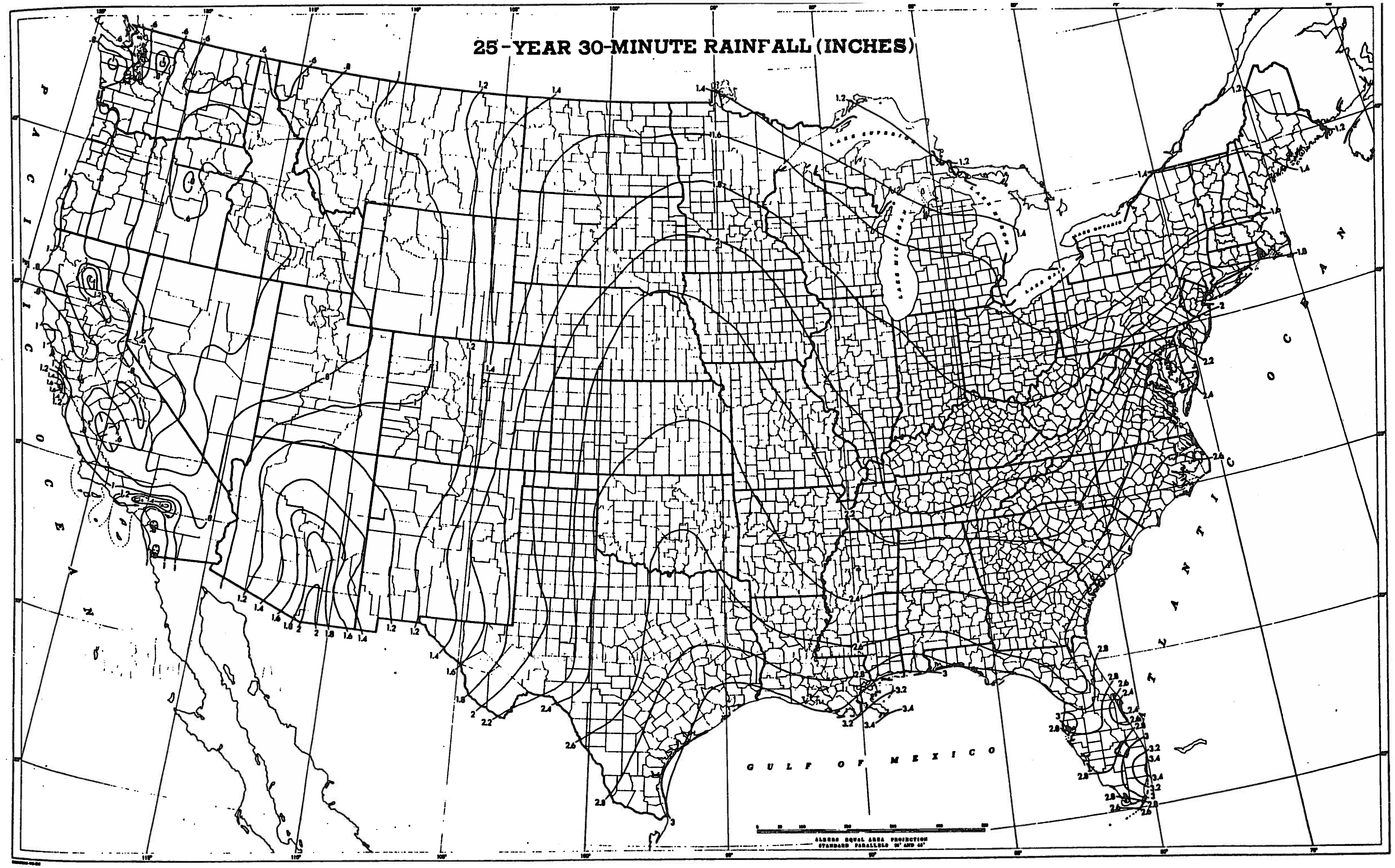

25-YEAR 30-MINUTE RAINFALL (INCHES)
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29° AND 45°

FIGURE 4.5 n Values for Riprap Lined Channels

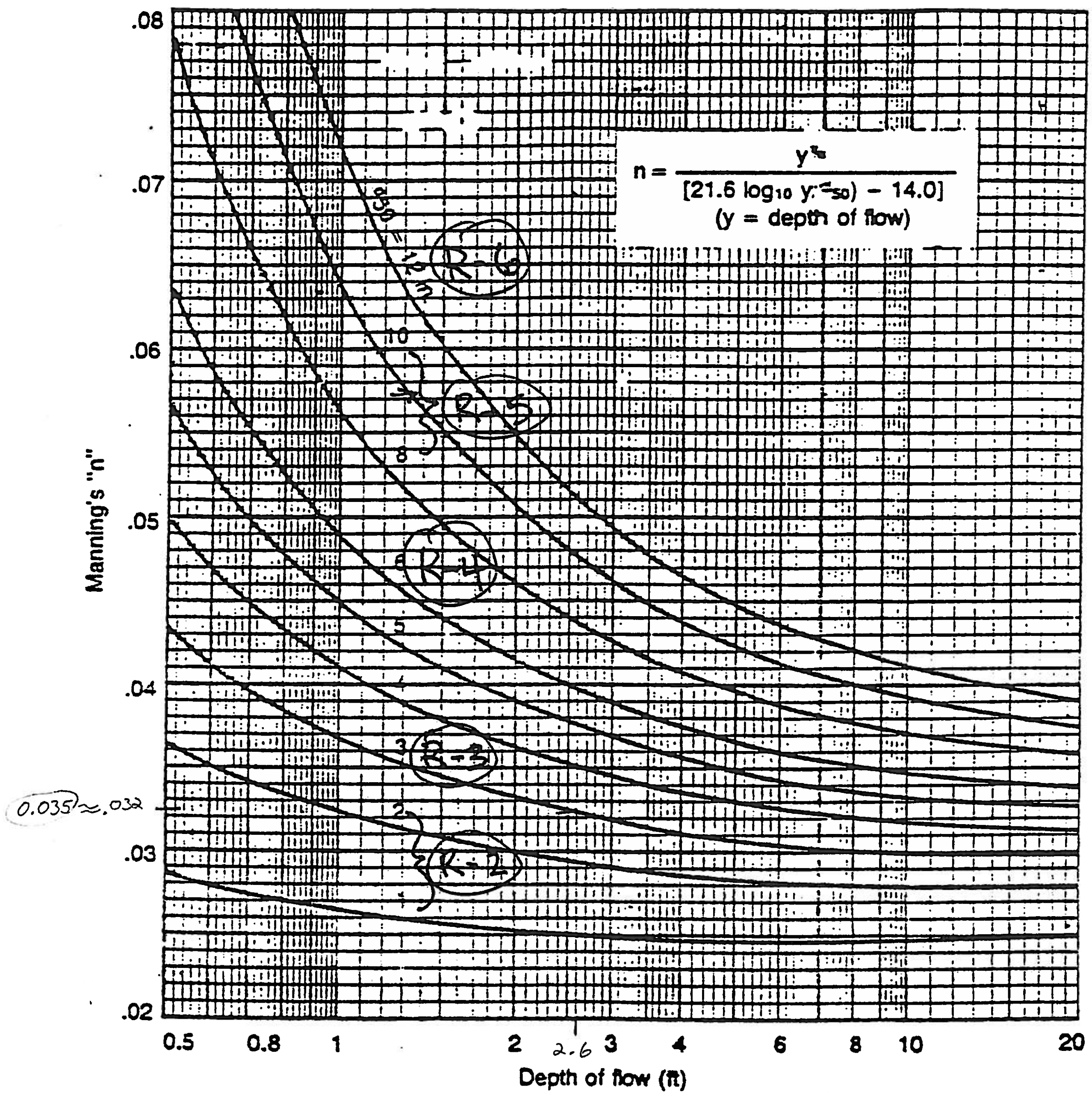


TABLE 4.7c Maximum Permissible Velocities for Rock Lined Channels and Riprap

NSA NO.	Graded Rock Size (In.) Max.	D_{50}	Min.	Permissible velocity fps*
R-1	1.5	.75	NO. 8	2.5
R-2	3	1.50	1	4.5
R-3	6	3	2	6.5
R-4	12	6	3	9.0
R-5	18	9	5	11.5
R-6	24	12	7	13.0
R-7	30	15	12	14.5

* Permissible velocities based on rock at 165 lbs. per cubic foot. Adjust velocities for other rock weights used. See Figure 4.6

TABLE 4.7d Maximum Permissible Velocities for Reno Mattress and Gabions

Type	n	Thickness inches	Rock fill Gradation-in.	Permissible* Velocity-fps
Reno Mattress	.025	6	3 - 6	13.5
	.025	9	3 - 6	16.0
	.025	12	4 - 6	18.0
Gabion	.027	18 +	5 - 9	22.0

* Permissible velocities may be increased by the introduction of sand mastic grout. Refer to manufacturers recommendations/specifications for permissible velocities.

APPENDIX B

ENGINEERING DESIGN DRAWINGS
(UNDER SEPARATE COVER)

APPENDIX C

OUTLINE OF ANTICIPATED TECHNICAL SPECIFICATIONS

ARVIN MERITOR
GRENADA, MISSISSIPPI
DESIGN FOR PERMEABLE REACTIVE BARRIER GROUNDWATER
INTERIM MEASURE
MAY 2001

DIVISION 0 - GENERAL CONDITIONS

DIVISION 1 - GENERAL REQUIREMENTS

DIVISION 2 - SITE WORK

APPENDIX D

CONSTRUCTION QUALITY ASSURANCE PLAN
(IN DEVELOPMENT)

APPENDIX E

PERFORMANCE MONITORING PLAN
(IN DEVELOPMENT)